By Land Or By Sea: An Analysis Of National Missile Defense Options

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EXECUTIVE SUMMARY

Title: By Land or By Sea: An Analysis of National Missile Defense Options

Author: Major Bern J. Altman, USMC

Thesis: In this paper, a comprehensive analysis will be made between the current administration's National Missile Defense plan and the proposal for a sea-based NMD system supported by The Heritage Foundation to determine if one system is indeed superior to the other.

Discussion: In conformance with the National Missile Defense (NMD) Act of 1999, the United States is pursuing the path to fielding a system capable of providing protection for all of the U.S. against a limited ballistic missile attack. The proposed land-based system is scheduled for a Deployment Readiness Review (DRR) in June 2000. As currently envisioned, the land-based system will rely on silo-based interceptors (most likely in Alaska) receiving guidance from a network of land-based radars, and eventually space-based sensors, to destroy incoming missiles. There are alternatives to the land-based system, the most prominent being a sea-based system building upon the Aegis Weapons System. With advocates both in and outside the Navy, the sea-based approach for many years has also been championed by The Heritage Foundation, a conservative Washington, DC-based think tank with influence on Capitol Hill and beyond.

This paper examines the comparative advantages and disadvantages of the current NMD plan and the proposed sea-based NMD system to determine their relative capability, deployability and overall viability.   Admittedly, not a trivial undertaking, the paper opens with a brief history of NMD, followed by a definition of the threat, and a summary of the current status of our ballistic missile defense efforts. Recommendations of The Heritage Foundation are then analyzed in some depth, followed by a comparison of the two systems in the following categories: performance of sensors, boosters and kill vehicles, projected timelines and costs, testing, technical hurdles, programmatic risk factors, capabilities against the threat, probability of kill, effectiveness against countermeasures, areas the systems can defend, operational security and challenges relating to both Command and Control and Concept of Operations.

Conclusion(s) or Recommendation(s): Although not each of the above categories should be weighted equally nor is the decision decisive in all cases, the land-based system was evaluated as superior in 11 of the 14 areas. Additionally, this systematic review produced very little concrete data to support Heritage Foundation claims about the

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ability to field a sea-based system quickly and cheaply. To the contrary, the analysis points to the following conclusions:

• The proposed land-based system could be fielded faster than any sea-based system with similar capabilities.

• The proposed land-based system will be able to meet the requirements for NMD at the three currently specified capability levels.

• The Navy Area Wide (NAW) and Navy Theater Wide (NTW) Block I systems will have no capability against ICBMs, and there is not currently any defined or funded program that would give sea-based missile defense systems this capability. However, with the addition of external sensor data and upgrades beyond the Block II capability, the NTW system could possess significant NMD capabilities.

• Though technically possible to expand NTW into a sea-based NMD system, even with an accelerated schedule this capability will not exist until after FY10.

• The current Aegis Weapon System could serve as a springboard for future sea-based missile defense systems, however many of the components would need to be replaced or significantly upgraded.

• Any sea-based system would rely heavily on the same external sensors, ground-based radar and SBIRS, and BM/C3 system as the proposed land-based system. As such the proposed sea-based system in fact only replaces one of the four elements of the current land-based proposal, the interceptor itself.

• Due to the specific stationing requirements essential for sea-based missile defense, it is not an efficient use of assets to utilize very expensive multi-mission ships such as Ticonderoga class cruisers and Arleigh Burke class destroyers for this mission.

• Neither of the proposed systems is capable of defending the United States from all ballistic missile threats. Either system could be overwhelmed by a relatively small number of missiles, particularly in the C-1 and C-2 configurations. Due to the shorter range and reduced time of flight of sea-launched ballistic missiles, the land-based system would be incapable of intercepting them. While the proposed sea-based system would be capable of this type of intercept, it is unlikely that sufficient sea-based assets would be continuously available or properly positioned to constantly defend the United States against this threat.

• A sea-based system would be complementary to a land-based system and would provide additional security in several ways. The sea-based system, if properly positioned, would counter the threat of shorter-range missiles launched at the United States from submarines or surface ships. It would allow the BMD to be weighted against a specific threat. It would be able to extend BMD to areas beyond the range of our land-based system. It would increase the overall effectiveness of the NMD system by providing

multiple engagement opportunities for ICBMs launched at the United States. Finally, a sea-based system would provide redundancy to the proposed land-based system.

The bottom line is that the United States is vulnerable to ballistic missile attack and grows more so every day. It is indeed unlikely that a country would launch an unprovoked attack on the U.S.; however, the threat of an attack has the potential to limit our freedom of action and options for responding to international crises

Given that there are clear advantages to both land-based and sea-based systems, the most logical decision would be to proceed along the path we are on (although not officially) with the development of both systems. This would most likely mean providing protection for the majority of the United States by means of a land-based system at one or multiple sites. To proceed down this path, however, the ABM treaty restrictions on both the land-based and sea-based systems need to be overcome and a plan must be implemented for the combined system, optimizing each component for those threats to which it is best suited.

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Preface

National Missile Defense (NMD) is a rapidly evolving issue with significant developments and changes, both technological and political, occurring weekly if not on a daily basis. Throughout the research and writing of this paper every effort was made to keep data current up to the minute. However, with the frequency and quantity with which new and significant information that bears directly on the content of this paper is being released, some information may rapidly become incorrect or out of date. The pace of this new information has continued to increase as the Ballistic Missile Defense Organization (BMDO) prepares for the Developmental Readiness Review scheduled for this June. In fact, in March, BMDO was scheduled to submit to Congress a report on the very same subject as this paper. Though it has yet to be released, it is intended to serve as a follow-on to last year's *Report to Congress on the Utility of Sea-Based Assets to National Missile Defense,* due in large part to the reports of The Heritage Foundation.

The desire to keep this paper unclassified also limited some of the analysis that was originally envisioned. This is particularly true in the area of Aegis radar capability and SM-3 interceptor performance. In cases such as these reasonable assumptions were made concerning those capabilities. Additionally, due to the rate of change, unavailability or level of complication of specific data sets much of the analysis became a subjective discussion of the topic verses an engineering analysis. It became apparent in the writing of this paper that this may in fact be a more useful approach. As the technology evolves

and the design and specifications for elements of both systems change, having an understanding of the concepts will allow the reader to apply the issues presented to the new circumstances.

In the development of this paper I would like to thank the many people who took the time to discuss these issues and provide their valuable thoughts and insights on the topic. Most important I would like to thank my wife who, as it happens, was the fact-checker on President Reagan's original SDI speech and who reviewed and corrected numerous iterations of this paper. While every effort was made to present this information in as clear and simple a manner as possible, the technical nature of this complicated subject proved to make this possibly the most arduous reading of her life. Hopefully, those with a professional background and stake in National Missile Defense will not find it so.

Chapter 1

National Missile Defense Options

> *It is the policy of the United States to deploy as soon as is technologically possible an effective National Missile Defense system capable of defending the territory of the United States against limited ballistic missile attack (whether accidental, unauthorized, or deliberate) with funding subject to the annual authorization of appropriations and the annual appropriation of funds for National Missile Defense.*
>
> National Missile Defense Act of 1999

In conformance with the National Missile Defense (NMD) Act of 1999, the United States is unquestionably pursuing the path to fielding a system capable of providing protection for all of the United States against a limited ballistic missile attack. The proposed land-based system is scheduled for a Deployment Readiness Review (DRR) in June 2000, after which President Clinton is expected to make a deployment decision.[1] As currently envisioned, this multibillion dollar system, which has its roots in President

[1] "The specific decisions to be made at the DRR are the commitment to deployment, element site selection, and authorization to proceed to contract award for site construction. Two other key decision points have been added on the path to a 2005 deployment. An FY01 decision will consider the building and/or upgrading of required ground radar systems and the integration of command and control software into the Cheyenne Mountain Operations Center. An FY03 decision will determine if the weapons system is ready for limited production and deployment." Department of Defense, Director of Operational Testing and Evaluation, *DOT&E FY99 Annual Report to Congress*, Washington, DC, February 1999, VI-6, URL <www.dote.osd.mil/reports/FY99/index.html> accessed 15 February 2000. Both pro and anti-BMD groups have questioned the timing for this decision shortly before the presidential election. Whether the technology and testing has advanced far enough to make this decision has also been questioned particularly in light of the recent failure of IFT-4 to intercept the target missile. President Clinton will base his decision on four factors (1) the technological readiness and operational effectiveness of the proposed system; (2) the projected cost; (3) a review of the threat; and (4) the international security situation, to include arms control. William S. Cohen, *Annual Report to the President and the Congress*, 69, URL <www.dtic.mil/execsec/adr2000> accessed on 12 March 2000.

Reagan's Strategic Defense Initiative of 1983, will rely on silo based interceptors (most likely in Alaska) receiving guidance from a network of land-based radars, and eventually space-based sensors, to destroy incoming missiles.

There are alternatives to the land-based system currently being developed, the most prominent being a sea-based system building upon the Aegis Weapons System. Sea-based NMD is not a new concept. As early as the 1960's, while the Army was running the national anti-ballistic missile (ABM) program, "The Navy hoped that Army BMD might lead to an eventual Sea-based Anti-ballistic missile System (SABMIS)."[2] While a sea-based system has strong advocates both in and outside of the Navy, The Heritage Foundation, a conservative Washington, DC-based think tank, has for many years been the most vocal advocate of this approach.

The Heritage Foundation maintains that theirs "is a comprehensive plan to build an effective, layered missile defense system that, for a fraction of the cost" of the current administration's proposal, "can effectively and quickly meet in the near term the threat that ballistic missiles pose today."[3] Their most recent report, *Defending America: A Plan to Meet the Urgent Missile Threat,* has drawn significant congressional interest. Partially in response to this influential paper, the Ballistic Missile Defense Office (BMDO) submitted a report to Congress in June 1999 recognizing the possible merits of sea-based

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[2] Edward Reiss, *The Strategic Defense Initiative,* (New York: Cambridge University Press, 1992), 24.
[3] The Heritage Foundation, *Defending America: A Plan to Meet the Urgent Missile Threat* (Washington, DC: The Heritage Foundation, 1999), viii.

NMD.[4] BMDO was slated to deliver a follow-up report on Sea-Based NMD in March 2000, however the Department of Defense has not released that report to Congress yet.[5]

In this paper, a comprehensive analysis will be made between the current administration's NMD plan and the proposal for a sea-based NMD system supported by The Heritage Foundation in order to determine if one system is indeed superior to the other. Advantages and disadvantages of both systems will be explored. In addition, those ballistic missile defense threats not covered by either system will be identified and recommendations to solve these shortcomings will be provided.

Beyond the discussion of whether a land-based or sea-based ballistic missile defense system is preferable, there is a more fundamental question on the wisdom of deploying a ballistic missile defense system at all. This debate has gone on since the plan was announced to deploy the Sentinel ABM system in 1967, and while the decision to deploy a NMD system is an extremely important question, this paper will assume the United States is going to follow the guidance specified in the 1999 NMD Act.

One political issue in particular, the Anti-Ballistic Missile (ABM) Treaty, cannot be entirely avoided. As the treaty is currently written and officially interpreted, it would completely eliminate the possibility of deploying a sea-based NMD system and would impose severe limitations on any land-based system eventually deployed. Since this treaty has had significant impact on development of the two competing systems to date, some discussion will be required in order to justify certain assumptions and analyses.

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[4] Department of Defense, Ballistic Missile Defense Organization, *Report to Congress on the Utility of Sea-Based Assets to National Missile Defense,* 1 June 1999, URL <www.acq.osd.mil/bmdo/bmdolink/pdf/seanmd.pdf> accessed 7 April 2000.

[5] Robert Holzer, "Report: Sea-Land Combo Best NMD for U.S.," *Defense News*, 6 September 1999, 3; Richard W. Davis, BGen, USAF, OSD, BMDO, Interviewed by author, 3 February 2000. "First By Sea," *Wall Street Journal*, 10 April 2000.

In order to perform a comparison of the two competing programs, some background material, both historical and technical, must be provided to support analysis later in the paper. A realistic and credible threat will be defined against which to assess the capabilities of the two competing systems. And a baseline will be provided, establishing the current status and developmental plans for both systems. This will lead into the introduction of The Heritage Foundation's sea-based NMD proposal followed by an analysis of the two competing systems. Finally, conclusions as to the capability, deployability and viability of the proposed land-based and sea-based NMD systems will be provided along with recommendations for future development and deployment.

Chapter 2

Fundamentals of National Missile Defense

History

> *Guided missiles, winged or nonwinged, traveling at extreme altitudes and at velocities in excess of supersonic speeds, are inevitable. Intercontinental ranges of over 3000 miles and payload[s] sufficient to carry atomic explosive[s] are to be expected. Remotely controlled, and equipped with homing devices designed to be attracted to sound, metal, or heat, such missiles would be incapable of interception with any existing equipment such as fighter aircraft and antiaircraft fire. Guided interceptor missiles, dispatched in accordance with electronically computed data obtained from radar detection stations will be required.*
>
> The Stillwell Board Report, November 1945[6]

In order to gain an appreciation for the immense technological difficulties involved in developing an ABM system, and to help understand how the current administration's proposed NMD system has come about, a brief history of ballistic missile defense is beneficial. The requirement for the capability to defeat ballistic missiles is not new. The threat posed by long-range ballistic missiles was accurately and concisely stated in the Stillwell Report of 1945. In spite of identifying the problem over 50 years ago and nearly continuous efforts since then to address the threat, only now is the technology becoming mature enough to provide a credible defense against the ballistic missile threat.

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[6] The Stillwell Board Report, November 1945, quoted in Department of Defense, Ballistic Missile Defense Organization, *Missile Defense Milestones 1944 – 1997*, URL <www.acq.osd.mil/bmdo/bmdolink/html/milstone.html> accessed 30 November 1999.

Ballistic missile defense research, programs and technology can be broken into two major phases. The first phase includes all systems up to and including those systems deployed but made operational for only several months following the ratification of the ABM treaty. The second phase would include all efforts following those pre-ABM treaty systems, the bulk of which began with President Reagan's Strategic Defense Initiative (SDI) in 1983. A significant difference in the two phases is that those in the first phase relied upon nuclear tipped interceptors, while those in the second phase primarily utilize hit-to-kill (HTK) technology.

Phase I

Defense is moral; offense is immoral!

Soviet Premier Alexsei N. Kosygin, 23 June 1967[7]

The Air Force explored ballistic missile defense as early as 1946 but terminated the Thumper and Wizard programs due to inadequate technology for radars, data processing and guidance systems.[8] However, ABM research and development continued and in 1956 the Army was designated to run the Anti-Ballistic Missile (ABM) program. Most of the Army's ABM work was based on the Nike anti-aircraft systems. An apparently successful program, the Nike-Zeus system claimed thirteen successful intercepts of ballistic missiles. As the program developed, Nike-Zeus became Nike-X in 1964, and in September of 1967 President Johnson made the decision to deploy the Sentinel ABM system.[9]

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[7] This statement was made at the Glassboro summit to President Johnson and Secretary of Defense McNamara when they expressed concern over Moscow's Galosh ABM system. Quoted from *Missile Defense Milestones 1944 – 1997.*

[8] Reiss, 22.

[9] Reiss, 22-29.

Bowing to the political concerns of the day, the Sentinel system's mission was very similar to the current ballistic missile defense program's goal. Sentinel was designed not to protect the United States from a Soviet attack, but to defend against an "Nth country threat," a limited attack by unsophisticated ICBMs. Also similar to the Navy's current theater missile defense plan, the Sentinel system was comprised of two types of interceptors, Spartan missiles for exoatmospheric intercepts and Sprint missiles for endoatmospheric intercepts.[10]

Sentinel was changed to Safeguard in 1969. While Safeguard retained the same interceptors as Sentinel, its mission was altered from defending the United States from the "Nth country threat" to defending American ICBM fields from a Soviet attack.[11] With the change in mission, the futility of defending against the Soviets rapidly became apparent. "The technology was immature and members of the administration had testified that the system would not be cost-effective at the margin. Indeed, the Director of Defense Research and Engineering (DDR&E) stated that the U.S. would have to spend four times as much to limit damage as the Soviets would have to spend to create damage."[12] Once more, as had been the case 20 years earlier, the technological shortcomings, this time coupled with political expediency, fouled the ABM effort.

A similar conclusion on the futility of defense against an all-out American missile attack was reached by the Soviets, who had deployed their Galosh ABM missile system around Moscow in 1967. It was apparent that the Galosh system would soon be overcome by U.S. development of Multiple Independently-targetable Re-entry Vehicles

[10] *Missile Defense Milestones 1944 – 1997*.
[11] *Missile Defense Milestones 1944 – 1997*.
[12] Reiss, 31.

(MIRVs) and deployment of the Minuteman III missile and Poseidon Submarine Launched Ballistic Missile.[13]

ABM Treaty

> *[We] have no choice but to conclude that the ABM treaty did not survive the dissolution of the Soviet Union. Accordingly it is our position that the ABM treaty has lapsed and is in no force.*

Letter from Republican leadership to President Clinton,
25 September 1998[14]

Recognition by both the United States and the Soviets of the technological limitations as well as the fiscal and political costs of establishing a credible ABM system led to the 1972 ABM treaty, which limited each side to two ABM sites. In 1973 Congress unilaterally restricted deployment of the United States ABM system to a single site at Grand Forks, North Dakota. The Soviet Union reciprocated and the 1974 protocol to the ABM treaty limited each side to a single ABM site. While the United States proceeded with the development of the ABM site at Grand Forks the decision was made not to maintain the NMD system even before it became operational, and in fact the Safeguard site was closed only five months after it became operational.

Although acknowledged to be ineffective against a U.S. attack, the Soviets continue to maintain and upgrade their Galosh ABM site. In response to recent ABM testing in the United States, several tests of this Moscow based ABM system were conducted on 3 November 1999, which the Russians claim were successful.[15] In addition to their Galosh ABM system, the ability of the Soviet SA-5 and SA-10 surface to air missiles to intercept ballistic missiles has been a contentious issue as the dual capabilities of these systems is

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[13] Reiss, 32.

believed by many to be a violation of the ABM treaty.[16] There are numerous other allegations of Russian violations of the ABM treaty, the most notable being the utilization of the Hen House and their successors, the Pechora-Krasnoyarsk class radars to provide ABM tracking.[17]

Some of the key restrictions contained in the ABM treaty and the 1974 protocols that have a significant impact on current American ABM efforts are as follows:[18]

- Article I prohibits deployment of ABM systems for territorial defense or for regional defense except as provided for in Article III (below).
- Article II defines an ABM system as a system to counter strategic ballistic missiles or their elements in flight trajectory, consisting of interceptor missiles, launchers and radars.
- Article III, as amended by a 1974 Protocol, limits each Party to a single ABM deployment site consisting of no more than 100 interceptor missiles, no more than 100 interceptor launchers, plus other specific limitations on ABM radars. Additionally the ABM site is limited to having a radius of one hundred and fifty kilometers and containing ICBM silo launchers or having a radius of one hundred and fifty kilometers and centered on the national capital.
- Article IV exempts limited numbers of ABM systems or components used for development and testing and located at agreed ABM test sites from Article III constraints.
- Article V prohibits the development, testing and deployment of sea-, air- or space-based and mobile ABM systems and components.
- Article VI prohibits giving ABM capabilities to non-ABM systems, prohibits testing non-ABM systems in an ABM mode, and limits deployment of early warning Large Phased Array Radars (LPARs) to each country's periphery, oriented outward.

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[14] Senators Trent Lott, Jesse Helms et al., *Letter to the President*, 25 September 1998, URL <www.clw.org/pub/clw/coalition/helm0303.htm> accessed 26 February 2000.
[15] David Hoffman, "Russia Test-Fires Interceptor Missile," *Washington Post*, 4 November 1999, Sec. A25.
[16] "SA-5 'Gammon' (S-200 Volga, 5V21/5V28)," *Jane's Strategic Weapons Systems*, vol. 30, 21 May 1999; "SA-10 'Grumble' (S-300, S-300 PMU, Buk/Favorit/5V55/48N6)," *Jane's Strategic Weapons Systems*, vol. 30, 21 May 1999.
[17] William T. Lee, "Russian Sources Confirm Massive Soviet ABM Treaty Violations," *The Shield*, Vol XVI, No. 2 (March/April 1999). This article was an update to William T. Lee, *The ABM Treaty Charade: A study in Elite Illusion and Delusion* (Washington DC: Council for Social and Economic Research, 1997). Additional material on Russian ABM Treaty violations is also included in Heritage Foundation publications.

Although the subject of intense political debate, the United States has continued to abide by the ABM treaty. Beyond adhering to the treaty, the current administration has continued to negotiate amendments to the treaty and signed four ABM Treaty Documents in 1997 that, if ratified by Congress, would further curtail the United States' ABM efforts.[19] The administration has not sent the amendments to Congress however, fearing they would be dead on arrival. Each one of the above listed restrictions, together with the current strict interpretation and adherence to the ABM Treaty and its unratified protocols, has affected and continues to impact the United States' ABM efforts. These restrictions are most severe on the development of sea-based ballistic missile defense systems, which have many more restrictions and are specifically prohibited from being given any capability to defend the United States from ICBMs.

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[18] Department of State, *Treaty Between The United States of America and The Union of Soviet Socialist Republics On The Limitation Of Anti-Ballistic Missile Systems*, 26 May 1972. URL <www.state.gov/www/global/arms> accessed 27 February 2000.

[19] On 26 September 1997 four ABM Treaty Documents were signed. "The Memorandum of Understanding Relating to the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems of May 26 1972" commonly referred to as "The Memorandum of Understanding On Succession" established that the Parties to the ABM Treaty shall be the United States, Belarus, Kazakhstan, the Russian Federation and Ukraine. "The First Agreed Statement of September 26, 1997, Relating to the ABM Treaty" specifies that lower velocity TMD systems with interceptor missiles whose maximum velocity does not exceed 3.0km/sec and that have not been tested against targets with velocities greater than 5.0km/sec or with a range greater than 3500km are ABM treaty compliant. Patriot PAC-3, THAAD and NAW fall into the category of lower velocity TMD systems and are considered compliant with this agreement. The "Second Agreed Statement of September 26, 1997 relating to the ABM Treaty" concerns higher velocity TBM systems (those with velocities greater than 3.0km/sec) and limits the velocities against which these systems are tested to 5.0km/sec and ranges less than 3500km. The NTW system currently falls into this category and with the current test schedule is considered to be compliant. This agreement also prohibits the deployment of space-based TBMD systems. Associated with the Second Agreed Statement, the "Agreement on Confidence Building Measures Related to Systems to Counter Ballistic Missiles Other Than Strategic Ballistic Missiles" was signed. This document was made up of two parts, a non-legally binding unilateral statement of plans by each Party and a joint statement on the annual exchange of information concerning certain plans. The most significant of the unilateral statements is that the United States has no plans to develop a TMD system with an interceptor velocity exceeding 5.5km/sec for a land-based system and 4.5km/sec for a sea-based system. This would cap development of NTW at current design levels for the SM-3 Block II which has a significantly lower velocity than would be required for many NMD intercepts and a lower velocity than could be achieved by future upgrades to the SM-3 missile. This information was derived from Department of State, Bureau of Arms Control Fact Sheets, URL <www.state.gov/www/global/arms/bureau_ac/factsheets_ac.html> accessed 27 February 2000.

The past cannot be changed, and the purpose of this paper is not to judge earlier decisions. Therefore what can be accomplished from this point forward will be the focus. In an effort to level the playing field and provide as fair a comparison as possible between land-based and sea-based systems, this paper is written based on the assumption that the ABM treaty is not a factor from this point on in the development, design and fielding decision of any future NMD system.

While this assumption is necessary for the purposes and scope of this paper, it is also applicable in the real arena of debate, as there is considerable legal precedent supporting this conclusion. The law firms of both Hunton & Williams and Feith & Zeil have each released legal memorandums concluding that the ABM treaty is no longer binding on the United States. The Hunton & Williams memorandum has been endorsed by former Attorney General Edwin Meese III, former Secretary of Defense Caspar Wienberger, and over 50 leaders and well known foreign policy experts including Jeane Kirkpatrick and, later, chief architect of the ABM treaty Henry Kissinger.[20] Kissinger has also stated that the ABM treaty "makes no sense in a multi-polar world of proliferating nuclear powers."[21]

Even if the ABM treaty is assessed to be still binding, there are provisions for amendment and review every 5 years in Article XIV, and provisions for withdrawal from the treaty in Article XV. In any case, as stated by Ambassador David J. Smith, "First, we are deluding ourselves that some NMD is possible under the ABM Treaty."[22]

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[20] The Heritage Foundation, *"A Plan to Meet the Urgent Missile Threat,"* 22.

[21] Henry Kissinger quoted in The Heritage Foundation, *Defending America: A Near and Long Term Plan to Deploy Missile Defenses*, (Washington, DC: The Heritage Foundation, 1995) 5.

[22] U.S. Congress, Senate, Committee on Armed Services, Subcommittee on Strategic Forces, *Remarks of Ambassador David J. Smith*, 105th Cong., 2nd sess., 1998.

Phase II

Wouldn't it be better to save lives than to avenge them?

President Ronald Reagan, 23 March 1983

The ABM treaty was of course a severe blow to ABM development within the United States although the core research program managed to survive.[23] ABM research made slight gains in the late 1970's, but it was not until President Reagan's Strategic Defense Initiative (SDI) speech on 23 March 1983, formalized in National Security Decision Directive 85, that NMD once more gained momentum.

While declining any specifics, President Reagan envisioned an elaborate multi platform, multi layered system capable of defending the United States from a massive Soviet attack. His challenge was,

> I call upon the scientific community in our country, those who gave us nuclear weapons, to turn their great talents now to the cause of mankind and world peace, to give us the means of rendering these nuclear weapons impotent and obsolete... I know this is a formidable, technical task, one that may not be accomplished before the end of the century.[24]

Through Reagan's presidency, SDI remained a controversial, politically charged issue. There were many doubts of the technical feasibility and lingering questions of the overall goals of the system. Perhaps the best description of the SDI effort, and a task it did in fact accomplish, is "a research program designed to explore the feasibility of a range of technologies that could contribute in the future to a defense against ballistic missiles."[25]

By the time President Reagan left office, the work of the Strategic Defense Initiative Office (SDIO) had brought six systems to demonstration/validation phase. These

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[23] Reiss, 32.
[24] Ronald Reagan, "Address to the Nation on Defense and National Security," 23 March 1983.

elements were to be developed as the "Phase One" system.[26] Although the elements and capabilities of the NMD program have undergone four major restructurings, each of the six elements of the initial Phase One system has contributed directly to the current system. In 1991, under President Bush, the goals of the NMD system were scaled back to what was referred to as Global Protection Against Limited Strike (GPALS). At the beginning of President Clinton's administration the SDIO was reorganized into the Ballistic Missile Defense Organization (BMDO) and the goal of actually deploying a NMD system was reduced to a technology readiness program. The Persian Gulf War demonstrated the United States' vulnerability to theater ballistic missiles and the limitations of the Patriot missile system to provide BMD. As a result of this when SDIO was changed to BMDO, theater missile defense became the number one priority ahead of NMD.[27] Table 1 outlines the evolution of the NMD program since President Reagan's decision to develop ballistic missile defenses.

Table 1: Evolution of the NMD System since the Beginning of the SDI

NMD PROGRAM	MISSION	DEFENSE
Phase One System (1987)	Enhance deterrence of a Soviet first strike	1000s of interceptors, ground and space based
Global Protection Against Limited Strikes (GPALS) (1991)	Protect against accidental or unauthorized launch	100s of interceptors, ground and space based
Technology Readiness (1993)	Prepare technology to reduce deployment time	Ground based system, deployment not considered
Deployment Readiness (1996)	Integrate systems; prepare to deploy three years after a future decision	10s of interceptors, ground based only

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[25] Leon Sloss and Seymour Weiss, "Strategic Defense: A Third View" in *The Technology, Strategy, and Politics of SDI*, ed. Steven J. Cimbala (Westview Press: Boulder, 1987) 52.

[26] Reiss, 180. An excellent discussion of the three-phase plan for a BMD system, advocated by the Strategic Defense Initiative is also contained in The Congressional Office of Technology Assessment, *SDI: Technology Survivability and Software*, (Springfield, VA, National Technical Information Service 1988) PB88-236245.

[27] U.S. Congress, House, National Security Committee, *Statement of Lt General Malcolm R. Oneill, USA, Director, Ballistic Missile Defense Organization: Ballistic Missile Defense: 12 Years of Achievement*, 4 April 1995, URL www.defenselink.mil/speeches/1995/t19950404-oneill.html> accessed 9 February 2000.

NMD Acquisition (DRR scheduled for June 2000)	Prepare for initial deployment in 2005	10s of interceptors, ground based only

Source: BMDO Fact Sheet: National Missile Defense Program Evolution

Ballistic Missile Physics, Kinematics and Theory

While it is in no way the intent of this paper to provide even a cursory education on the physics and design of ballistic missiles, there are some basic issues that must be understood to support future analysis. The following discussion will briefly explain several basic concepts.

A ballistic missile has three phases of flight: boost, midcourse and terminal.[28] For reference purposes, Table 2 contains flight times in each phase for a notional 600km and 12,000km missile. These figures provide an insight into the engagement timelines required for intercepting ballistic missiles in various phases of flight. It is notable that an ICBM with 20 times the range of a theater missile is only in boost for approximately twice as long. Theoretically, different systems can destroy ballistic missiles in any of their three stages of flight, and there are advantages and disadvantages to intercepting during each phase.

Table 2: Ballistic Missile Time of Flight (seconds)

	Boost	**Midcourse**		**Terminal**
	Ascent Phase			
TBM (600 km)	100	200		50
ICBM (12000 Km)	200	1200		50

Source: Lincoln Laboratory [29]

[28] Some references also define a post-boost phase, which is after booster burnout but prior to separation of MIRV's, sub-munitions or decoys. A post-boost phase intercept has some of the advantages and disadvantages of the boost and midcourse intercepts.

[29] Massachusetts Institute of Technology, Lincoln Laboratories, *BMD Briefing*, presented to the Navy Missile defense Data Collection Team, Arlington, VA, 5 March 1999.

Overall, the most advantageous time to destroy a ballistic missile would be during its boost phase. During this time the missile is slower moving, easier to track due to the hot exhaust plume, has not yet deployed MIRVS, sub-munitions and penetration aides, and any residual chemical/biological/nuclear material will fall back onto the launching country's territory. This early intercept would also allow a layered defense with multiple shot capability and it may provide both national and theater defense in one system. The disadvantages of boost phase intercepts are the required interceptor locations, very close to threat launch sites, and the extremely high speed required of the interceptor.

Theoretically, forward or space-based interceptors could complete boost phase intercepts. However, due to the limited duration of the boost phase, the ambiguity in missile course in the early portion of the boost phase, the time required to detect, and track the missile then cue and launch the interceptor, boost phase intercepts are unrealistic for either of the systems discussed here. Realistically, a laser system either airborne or space-based would be required for a boost phase intercepts.

An ascent phase intercept refers to destroying the missile in the boost, post-boost or early midcourse phases of flight while the missile is still climbing. While not as advantageous as an intercept would be in the boost portion of the ascent phase, even post-boost it might be possible for an ascent phase interceptor to destroy a missile before decoys, MIRVs or sub-munitions are deployed. If this is not the case, an ascent phase intercept still destroys missiles earlier in flight and increases the opportunities for a layered defense to reengage targets. The ascent phase intercept is one of the key benefits claimed for the proposed sea-based system. The disadvantages of forward deployment of

interceptors, some knowledge of the launch location and the requirement for a more responsive command and control system still exist.

The advantages of a midcourse intercept derive from the length of time the missile spends in this stage of flight. This window provides adequate time for detection, tracking, weapon tasking and, with adequate sensors and fast long-range interceptors, the opportunity to engage, evaluate and re-engage the target. There are however several disadvantages. The missile would have had time to deploy warheads and countermeasures, which will all track along the same ballistic trajectory as the warhead creating a complex discrimination problem. Midcourse intercepts also require multiple, linked long-range sensors. Both the land- and sea-based proposals would be capable of midcourse intercepts.

The final phase of the intercept is the terminal phase, once the interceptor has reentered the atmosphere. Advantages of the terminal intercept include: the atmosphere will strip away all light decoys; it takes place at a relatively short-range allowing smaller sensors and interceptors; and due to aerodynamic heating the warhead has a bright Infra-Red (IR) signature. Disadvantages are that the warhead is capable of intentional or unintentional maneuvering, complicating the intercept;[30] any residual chemical/biological/nuclear material will still fall in the target area; and salvage fused nuclear warheads could still cause significant damage against soft targets.[31] Even though terminal phase interceptors such as Patriot or the NAW are the most developed ABM capability, this type of defense would require thousands of batteries to defend the United

[30] In the Persian Gulf War the unintentional aerodynamic maneuvering, after they broke apart, of the then unstable SCUD missiles is believed to have been one of the reasons the Patriot missiles were unable to intercept them. Michael A. Dornheim, "Missile Defense Design Juggles Complex Factors," *Aviation Week and Space Technology*, 24 February 1997, 56.

States, as a single battery could defend at most a single large city.[32] Neither of the proposed NMD systems is designed to be capable of a terminal intercept.

A ballistic missile can be fired on one of three trajectories. Normally a ballistic missile is fired on what is referred to as a "minimum energy" trajectory, which gives it the longest range. Alternatively, to defeat ABM systems, they can be fired at a higher angle "lofted" trajectory, or at a lower angle "depressed" trajectory. These alternate trajectories can significantly affect the capabilities to defend against them.

The lofted trajectory makes ascent phase intercepts more difficult by increasing distance from the missile to the interceptor until the missile is at a higher altitude and traveling at a greater speed. Likewise it makes terminal defense more difficult because the warhead is traveling faster and spends less time in the terminal phase. Lofted missiles spend more time in the midcourse phase providing an advantage to this type of intercept.

Depressed trajectory missiles travel faster and spend less time in the midcourse phase. Depending on the location of the launcher, the target and the interceptor site, it is possible to fire a depressed trajectory missile under the coverage of the interceptor. Both lofted and depressed trajectories reduce the overall range of the missile. While it is entirely situation dependent, use of alternate trajectories could reduce the effectiveness of either type of proposed NMD system.

Ballistic missiles can be intercepted within earth's atmosphere, endoatmospheric; or outside of earth's atmosphere, exoatmospheric. As shown in Table 3, the altitude at which an interceptor is designed to work has a significant impact on the sensors,

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[31] A salvage-fused warhead is designed to detonate if intercepted.

[32] Stephen Weiner, "Systems and Technology," *Ballistic Missile Defense,"* eds. Ashton B. Carter and David N. Scwartz (The Brookings Institute: Washington DC, 1984), 64.

maneuvering systems, defended area and impact of decoys. Both proposed NMD systems are capable of only exoatmspheric intercepts.

Table 3: Function of Altitude on Interceptor Performance

Altitude	**Atmospheric Effects**	**Aerodynamic Maneuvering**	**Decoys**	**Location of Intercept**	**Defended Area**
0-40km (Patriot, NAW)	Infrared sensors blinded by aerodynamic heating.	Aerodynamic maneuvering by the warhead intentional or not may make it difficult to hit.	Lightweight decoys stripped away.	Close to defended area. Debris may still fall on target. Little time for kill assessment	Small. 10's of Km.
40-80km (THAAD)	Weak aerodynamic effects. Infrared sensors will work if adequately protected.	Insufficient density for aerodynamic maneuvering.	Sufficient density to strip away lightweight decoys.		
80-100km (NTW, NMD either land or sea-based)	None	Thrusters required for maneuver.	Decoys will remain with warhead.	Far enough away so debris probably won't cause damage. Allows for kill assessment and re-engagement. May be beyond radar range. Short-range missiles spend little to no time in this region.	Large defended area.

Source: Aviation Week and Space Technology[33]

A number of factors affect the ability of an ABM to successfully complete the intercept. The most obvious is speed. Although there are other factors that apply, the range of a ballistic missile is largely governed by its velocity at booster burnout, V(bo). Therefore, due to their longer range, ICBMs are inherently much faster than TBMs. To maintain a large intercept window for these faster targets, a faster interceptor must be

[33] Dornheim, 54-55.

used and the closing velocity for an ICBM intercept can exceed 14 km/sec.[34] For comparison, Table 4 provides the velocities for some common objects as well as several types of ballistic missiles.

Table 4: Velocity Comparison

	Range (km)	Vel(km/s)	MPH	Mach
1st Indy Winner		0	67	0.09
Speed of Sound		0.3	761	0.99
Generic Rifle Bullet		0.6	1,365	1.78
Airspeed Record (SR-71 in 1976)		1	2,192	2.85
1st V2 prototype (3 Oct 42)		1.5	3,311	4.31
SCUD-B	300	1.5	3,311	4.31
Nominal V(bo) SM-2 Blk IVA		**1.7**	**3,803**	**4.95**
Nominal V(bo) THAAD		**2**	**4,474**	**5.83**
Al-Hussein	600	2.2	4,921	6.41
No-Dong	1100	3	6,711	8.74
Nominal V(bo) SM-3 Block I		**3.2**	**7,159**	**9.32**
Nominal V(bo) SM-3 Block II		**4.5**	**10,067**	**13.11**
CSS-2	3100	4.5	10,067	13.11
Speed Limit for ABM compliant targets		5	11,185	14.56
X-33 single stage to orbit prototype		5.2	11,521	15
Nominal V(bo) GBI		**6**	**13,422**	**17.48**
Notional ICBM	10000	7.2	16,106	20.98
Space Shuttle max re-entry velocity		8.4	18,746	24.41
SS-N-25	10000	8.5	18,969	24.70
Nominal closing velocity terminal ABM intercept		10	22,370	29.13
Earth Gravitational Escape Velocity		11	24,607	32.04

Source: Various, including Aviation Week & Space technology[35]

A related issue is the divert capability of the interceptor. Divert capability is the ability of the interceptor to alter and adjust its course following its initial boost and separation from the booster rocket. Factors requiring increased divert capability include ambiguity or inaccuracy in establishing the target's track prior to interceptor launch, and late detection of the reentry vehicle.

[34] Dornheim, 54.
[35] Dornheim, 56.

Beyond speed, the size of the ballistic missile target signature directly impacts the ability of sensors to detect and track it. As ICBMs always utilize separating warheads, following the boost phase, the ICBM presents a much smaller target to both radar and IR sensors than its shorter-range counterparts. In addition to being smaller, a highly streamlined ICBM warhead has a reduced radar cross section (RCS) which once more significantly affects the ability of radar to detect it, and it is also cooler, further reducing the IR sensor's ability to observe the target. Table 5 provides notional detection characteristics for the type of threat to be engaged by NAW, NTW and NMD type systems.

Table 5: Target Detection Characteristics

Characteristic	**NAW class Targets**	**NTW class Targets**	**NMD class Targets**
Closing Velocity (km/sec)	4	5	10
ReentryVehicle RCS (dBsm)	-10	-20 to -10	-30 to -10
Area (sq m)	1 to 2	0.5 to 2	.25 to 1
Temp (deg K)	400-500	300 to 350	250 to 300

Source: Various

The primary functions any BMD system must perform are target acquisition, tracking, discrimination, interceptor control, and target kill.[36] The systems sensors must have sufficient range to allow those functions to take place within the kinematic capabilities of the interceptor. For very fast ICBMs this dictates either remote sensors and/or extremely long-range collocated sensors. The long-range detection problem is compounded if the capability to reengage targets missed during the first intercept attempt is desired. The proposed land-based system is designed with a very capable sensor package as required for multiple intercept opportunities. In order for the proposed sea-

based system to have a NMD capability it would require a similar sensor capability to be developed.

All of these factors, phase of flight, missile trajectory, intercept altitude, and warhead signature versus sensor capability, will affect the area that an ABM system can defend. This myriad of factors physically prevents any single system from being capable of defending against all ballistic missile threats. This makes it essential to properly define the threat and optimize the system against that particular threat, knowing that this system may have no capability against other ballistic missile threats. Understanding the compromises that must be made in ballistic missile defense is an extremely important concept that must be considered throughout the remainder of this paper.

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[36] Weiner, 54-55.

Chapter 3

Defining the Threat

> *We are affirming that there is a threat, and the threat is growing, and that we expect it will soon pose a danger not only to our troops overseas but also to Americans here at home…. On August 31st, North Korea launched a Taepo Dong 1 missile….The Taepo Dong 1 test was another strong indicator that the United States in fact will face a rogue nation missile threat to our homeland against which we will have to protect the American People.*
>
> William S. Cohen, Secretary of Defense, January 20, 1999[37]

> *Some 25 to 30 countries either have or are seeking to acquire ballistic missiles, an enticing supplement to relatively modest armies, navies, and air forces. Like cruise missiles, ballistic missiles can be launched from land, sea, or air and have the flexibility to carry chemical, biological, or nuclear warheads. And they have the compelling advantage of being certain to arrive at their destinations-there being no defense against them.*
>
> Donald Rumsfeld, January 1999 [38]

The Threat

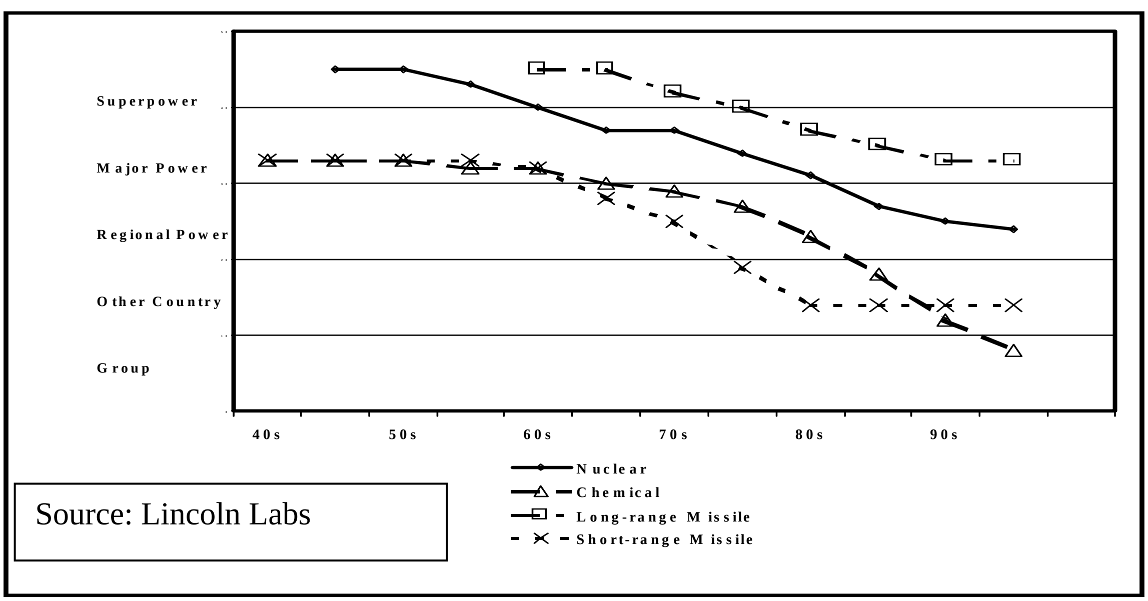
The Persian Gulf War demonstrated the political and strategic impact of even very low-tech inaccurate medium-range ballistic missiles, when coupled with the possibility of weapons of mass destruction (WMD) warheads. Since that time the number of countries possessing short and medium-range missiles and the capabilities of those missiles has

[37] Department of Defense, news briefing by Secretary of Defense William S. Cohen, Washington, DC, 20 January 1999.

[38] Donald Rumsfeld, "Surprise, Surprise: When it Comes to Ballistic Missile Proliferation, Expect the Worst," *The Shield*, Vol. XVI No. 1 (January/February 1999).

been rapidly expanding. Currently 25 to 30 countries possess or are in the process of developing ballistic missile technology, buying the technology and components to build ballistic missiles, or outright purchasing very capable short and medium-range ballistic missile systems. In addition to their current capabilities, several countries are developing long-range missiles that may soon have the capability of threatening all of Europe and at least parts of the United States. Several of the countries pursuing these missiles, including North Korea, Iran, and Iraq, have interests inimical to the United States. Appendix A provides a list of these countries and the capability of their current ballistic missiles. Additionally, Figure 1 provides a graphical depiction of how ballistic missile and WMD technology has migrated to lesser-developed countries over the last half-century.

Figure 1: Diffusion of Technology



At this point there is little dispute as to whether the United States will face a ballistic missile threat to one or all fifty states. The only question currently debated is when that threat will emerge. In 1995 the Central Intelligence Agency produced a National Intelligence Estimate (NIE) that concluded "No country, other than the major declared nuclear powers, will develop or otherwise acquire a ballistic missile in the next 15 years that could threaten the contiguous 48 states and Canada."[39] The accuracy of that estimate was immediately challenged by numerous organizations including The Heritage Foundation. The CIA estimate was most recently contradicted by the *Report of the Commission to Assess the Ballistic Missile Threat to the United States*, better known as the Rumsfeld Commission Report, released in June 1998, which estimated that threat to be as little as five years away.[40] Specific findings of the Rumsfeld commission include:

> • Concerted efforts by a number of overtly or potentially hostile nations to acquire ballistic missiles with biological or nuclear payloads pose a growing threat to the United States, its deployed forces and its friends and allies. These newer, developing threats in North Korea, Iran and Iraq…would be able to inflict major destruction on the U.S. within about five years of a decision to acquire such a capability (10 years in the case of Iraq). During several of those years, the U.S. might not be aware that such a decision had been made.[41]
>
> • The threat to the U.S. posed by these merging capabilities is broader, more mature and evolving more rapidly than has been reported in estimates and reports by the intelligence community.
>
> • The intelligence community's ability to provide timely and accurate estimates of ballistic missile threats to the United States is eroding. This erosion has roots both within and beyond the intelligence process itself.

[39] Central Intelligence Agency, *Emerging Missile Threats to North America During the Next 15 Years*, NEI 95-19, November 1995, URL <www.fas.org/spp/starwars/offdocs/nie9519.htm> accessed on 22 November 1999.
[40] U.S. Congress. House, *Executive Summary of the Report of the Commission to Assess the Ballistic Missile Threat to the United States*, 15 July 1998, URL <www.fas.org/irp/threat/bm-threat.htm> accessed 30 June 1999.
[41] The Heritage Foundation has assessed that without inspections Iraq should be moved into 5-year category.

The community's capabilities in this area need to be strengthened in both resources and methodology.

• The warning times the U.S. can expect of new, threatening ballistic missile deployments are being reduced. Under some plausible scenarios…the U.S. might well have little or no warning before operational deployment.

Further complicating both threat assessment and the prevention of proliferation of ballistic missiles in the future is the similarity between ballistic missiles and non-military space launch vehicles.[42] Several countries, including most recently South Korea, have embarked on programs to develop a space launch capability.[43]

While attention is normally focused on the long-range ballistic missile threat to the United States, there are other ballistic missile threats to consider. According to the CIA, "Several countries are capable of developing a missile launch mechanism to use from forward based ships."[44] Although technologically more difficult, there is also the possibility of a submarine launched ballistic missile threat. For example, China is in the process of building the Type 94 missile submarine and developing the Julang JL-2 (Great Wave) submarine launched ballistic missile.[45]

Many countries with ballistic missile programs and particularly those most threatening to the United States, including both North Korea and Iran, are also developing nuclear, chemical, or biological weapons of mass destruction. While a

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[42] Heritage Foundation, *A Plan to Meet theUrgent Missile Threat*, 8-9.

[43] Calvin Sims, "South Korea Plans To Begin Rocket Program," *New York Times*, 15 January 2000.

[44] Central Intelligence Agency, National Intelligence Council, *Foreign Missile Developments and the Ballistic Missile Threat to the United States Through 2015*, September 1999, 14, URL <www.cia.gov/cia/publications/nie/nie99msl.html,> accessed 7 April 2000.

[45] The JL-2 is an underwater variant of the DF-31. The DF-31 was first flight-tested August 99 and the Chinese are preparing for first test of JL-2. The Type 94 submarine is expected to be deployed 2005-2006 with 12-16 missiles. The missiles probably use stolen W-88 warhead technology and may have a range as great as 7400 miles. Type 94 will also incorporate Russian nuclear and propeller technology. China currently has 1 missile submarine, the Xia Class. Allegedly in disrepair and rarely leaves port. A second Xia class is also reportedly being built which will be capable of firing JL-2. Bill Gertz, "U.S. Secrets Aboard Latest Chinese Sub," *Washington Times*, 6 December 1999.

ballistic missile may possess tactical capabilities without a WMD warhead, its strategic impact is marginalized, particularly for ICBMs capable of hitting the United States. Since the reason rogue nations desire ballistic missiles is assumed to be strategic, it is therefore essential that these missiles have a WMD warhead in order to have the desired effect of limiting the United States' ability to take action.

While in the Persian Gulf War Sadam Hussein was able to achieve some strategic effect on Allied operations through the use of his Scud missiles with high explosive warheads, it was primarily the fear that they may have chemical warheads that gave them that leverage. As expressed by a former Chief of Staff of the Indian Army, "These lessons will not be lost on rogue leaders. The Gulf War emphasized once again that nuclear weapons are the ultimate coin of power. In the final analysis, they [the Americans] could go in because the United States had Nuclear Weapons and Iraq didn't."[46]

In his testimony before the Senate Committee on Armed Services, Ambassador David J. Smith's discussion of this issue further supports this argument.

> I do not believe that China, Iran or Libya or most potential adversaries are going to acquire an ICBM to lob at the United States in a lash out of techno-terrorism. (Although, one should probably not discount the notion for a country like North Korea.) But for most potential adversaries, suitcase bombs, car bombs, vials of anthrax and maybe even malicious hackers are available to commit acts of terrorism – and are all perils against which we must guard. But these are not the tools of geopolitical strategy. Regimes which perceive their interests at odds with ours want ballistic missiles to wield in a regional crisis to alter America's calculation of its own interests–to keep us out. Right now the price of entry to the

[46] *Defending America: A Near and Long Term Plan to Deploy Missile Defenses*, 9. Selig S. Harrison and Geoffrey Kemp, "India & America After the Cold War," Carnegie Endowment for International Peace, 1993, 20.

> club of countries which can aspire to deter the United States is one long-range missile and one weapon of mass destruction.[47]

To further demonstrate the importance of WMD warheads, as can be seen in Table 6, in previous conflicts, the use of hundreds or thousands of ballistic missiles with conventional warheads did not produce the desired strategic effect. Also, the attacks produced relatively light casualties considering the missiles were primarily being used as weapons of terror and targeted large population centers. The German V2 attacks caused under 3000 fatalities and the Iraqi attacks in the war of the cities caused slightly over 2000.[48]

Table 6: Ballistic Missile Use in Previous Conflicts

Campaign (Missile Type)	Campaign Duration	TBMs Fired	Max/ Day	Fatalities	Targets
WWII (V2)	7 Months	2600	26	2754	Cities, Ports
Iran-Iraq War of the Cities (SCUD + Mods)	6 Weeks	350	11	2226	Cities
Afghanistan (SCUD)	2 Years	1600	13	Unknown	Villages, Troop Concentrations
Desert Storm (SCUD + Mods)	6 Weeks	86	10	44	Cities, Ports, Airfields

Source: "TBMD Could Backfire" and Lincoln Labs

Given our uncontested nuclear superiority and ability for massive retaliation it may seem unlikely that another country would threaten a WMD attack on the United States; however this has already occurred. In 1996 China alluded to an attack on Los Angles if the United States intervened in their dispute with Taiwan.[49]

Another source of concern is that since the end of the Cold War the Russians' early warning network has unquestionably deteriorated. According to one expert on the

[47] U.S. Congress, Senate, *Remarks of Ambassador David J. Smith*.
[48] D.H.L. MacDonald, "TBMD Could Backfire," *Proceedings*, April 1998, 81-82.
[49] Gen. Xiong, Deputy Chief of Staff for Intelligence of the Peoples Liberation Army, is known for making the remark to a former Pentagon official. The statement was reported to the White House as a threat to use nuclear weapons against the United States. Heritage Foundation, *Defending America: Ending America's Vulnerability to Ballistic Missiles*, (Washington, DC: The Heritage Foundation, 1996) 1; Bill Gertz and

subject, “At most four of Russia’s 21 early warning satellites are still working…That gives Russian commanders no more than 17 hours—and perhaps as little as 12 hours—of daily coverage of the 550 nuclear tipped silos…Against submarines, they basically have no warning.”[50] In order for deterrence to be effective, both sides must have the capability of a retaliatory strike. This limited early warning system greatly reduces the Russians’ ability to detect and react to a United States first strike. Further limiting the Russians’ ability to counter an American first strike is the rapidly deteriorating condition of her strategic submarine forces, which during the Cold War would have been the most survivable weapons.[51] Both of these conditions create instability, and former Ambassador James Goodby, negotiator of the U.S.-funded destruction of Russian nuclear weapons, recently stated, “I think the chances (of a nuclear mistake) are rising…from what I felt was a very, very low level.”[52]

One hotly debated issue is the ability of the threat to develop and field decoys onboard their long-range missiles. One corner maintains that this is relatively simple and any country capable of developing a ballistic missile would be equally capable of producing simple lightweight and effective decoys. The other corner maintains that developing decoys with characteristics similar enough to the actual reentry vehicle to defeat our systems is extremely difficult and beyond the capability of any nation other

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Willis Witter, “U.S. Protests China’s Missile Help For North Korea,” *Washington Times*, 7 Jan 2000 sec. A3.

[50] Theodore Postol, a Massachusetts Institute of Technology professor who studies Russia’s early warning system, quoted in, “Russia Growing Blind to Missiles,” *Omaha World Herald*, 10 January 2000.

[51] At a Cold War high the Soviet Union possessed 69 SSBNs with 949 missile tubes and 2,956 warheads. Currently, Russia theoretically possesses 26 SSBNs with 440 missile tubes and 2,272 warheads. However as many as 10 of those submarines, including 5 of the 6 Typhoon class, are being dismantaled, converted, in overhaul, or are believed unfit for service, leaving Russia with an effective SSBN force of 16 submarines with 260 missile tubes and 1,036 warheads. Federation of American Scientists, “Status of Nuclear Powers and Their Nuclear Capabilities,” URL <www.fas.org/nuke/guide/summary.htm> accessed on 27 March

than Russia or possibly China.[53] However, as both proposed systems are primarily midcourse intercept systems where decoys are most effective, their presence must be taken into account, and while it cannot be absolutely stated what the extent of the decoy discrimination problem will be, it will represent a challenge not normally found in shorter-range ballistic missile systems.

Assumptions about the Threat

Some of the current threat assessments have been given above. There is certainly room for debate over exactly when the United States will be threatened by ballistic missiles and what the extent of that threat will be. However, in developing a defense it is only prudent to assume the worst case possible. In the case of defending the United States from ballistic missile attack, for the purpose of this paper, it will be assumed that the ballistic missile threat to the United States will include all of the following:

- Rogue nations possessing a few ICBMs with a range capable of striking all or part of the United States;
- The possibility of an accidental or unauthorized ballistic missile launch from either Russia or China;

2000; Natural Resources Defense Council, "US and USSR/Russian Strategic Offensive Nuclear Forces, 1945-1996," URL <www.igc.apc.org/nrdc/nrdcpro/nudb/dainx.html> accessed 27 March 2000.

[52] "Russia Growing Blind to Missiles."

[53] Concern about the effectiveness of countermeasures has been noted by authorities on the subject such as George N. Lewis, director of the MIT Arms Control Studies program and Greg Canavan, a senior scientist at Los Alamos National Laboratory both of whom believe, "The big concern is not hit-to-kill performance, it's dealing with countermeasures." Dornheim, 56. Additionally, virtually every opponent to a NMD system proclaims the simplicity and effectiveness of countermeasures. On the other side of the debate, Stanley Orman, the chief engineer responsible for the development of Chevaline, a penetration aid for the United Kingdoms, Polaris C-3, SLBM program, presents a strong case on the difficulties involved in the 13-year development of that decoy system and the difficulties in developing realistic decoys. Stanley Orman, "Defeat of Missile Defenses Not as Simple As Portrayed," *Defense News*, 6 September 1999.

• A sea-launched missile capability from either submarines or surface platforms; these missiles could be long, medium or short-range.[54]

• Any country launching a ballistic missile attack against the United States would have the capability of doing so with weapons of mass destruction.

• There will be an attempt to limit the capability of the United States NMD capability either through the use of decoys, penetration aids, and physical or electronic attacks on NMD systems to include satellites.

Purpose of the Proposed NMD System

Given this threat assessment, it is vital that we develop and deploy an NMD capability prior to other nations deploying their ballistic missile and possibly opening a window of vulnerability during which time the United States could be made powerless to react to a regional crisis. Once more, assuming the worst case, the window of vulnerability could occur by 2005 or earlier.[55] The deployed NMD system must be highly reliable, well protected, continuously available and capable of defending the United States from a limited ballistic missile attack from all regions of the globe, and must be available very soon. The system, however, need not be capable of providing defense against a significant Russian attack. While it may be desirable to blunt a Chinese attack, and the proposed architectures may provide that capability against the current

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[54] The requirements to intercept a missile launched from either a ship or submarine are essentially the same, however the capability to launch from a ship is attained much more easily and it is felt some rogue nations already have this capability. The U.S., France, Great Britain, Russia and China are the only countries possessing the technology to launch missiles from submarines and even China does this with great difficulty. India is also working on a SLBM and my have this capability within a decade. National Air Intelligence Center, *Ballisitc and Cruise Missile Threat, 1980*: NAIC-1031-0985-98, URL <www.fas.org/irp/threat/missile/naic/part06.htm> accessed on 30 June 1999; Gertz, "U.S. Secrets Aboard Latest Chinese Sub."

[55] U.S. Congress, House, *Report of the Commission,* 3.

Chinese threat, with Beijing's development of new solid fueled ICBMS and a more capable SLBM it is unlikely the system will have that capability by the time it is fielded.[56]

[56] In addition to the JL-2 SLBM program China has recently tested the DF-31, a 5000km solid fueled ICBM, and it is believed the DF-41 with a range of up to 8000km will be fielded by 2005. Richard D. Fischer, Jr., Baker Spring, *China's Nuclear and Missile Espionage Heightens the Need for Missile Defense*, Backgrounder, no. 1303 (Washington, DC: Heritage Foundation, 1999), 1.

Chapter 4

Current Status of Ballistic Missile Defense Systems

> *The primary mission of the NMD system being developed is the defense of the U.S. – all 50 states – against limited strategic ballistic missile attack such as could be posed by a rogue nation. Such a system also would provide some capability against a small accidental or unauthorized launch of strategic ballistic missiles from more nuclear capable states.*
>
> William S. Cohen, Secretary of Defense, February 2, 1999[57]

Up to this point it has been established that the United States is proceeding with the development of a NMD system. Based upon the results of the Deployment Readiness Review and the decision of the President of the United States this summer, there may be a decision to deploy an NMD system by FY05. It has also been established that there is a credible threat, and for the purposes of the comparison to be made in this paper, the capabilities of that threat have been defined. This chapter will discuss the Ballistic Missile Defense Organization, the agency responsible for developing all ballistic missile technology, and then provide a description and status report on the key elements of both the proposed land-based system and those components of the Navy Theater Wide system required for sea-based NMD.

During the past decade-and-a-half there have been significant advances in the state of the art, although the ability to destroy a ballistic missile in flight continues to be a

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[57] Department of Defense, Ballistic Missile Defense Organization, *National Missile Defense Program*, Fact Sheet, March 1999, URL <www.acq.osd.mil/bmdo/bmdolink/pdf/jn9905.pdf> accessed on 18 March 2000.

monumental challenge. In discussing the NMD system, the Pentagon's acquisition chief, Jacques Gansler, referred to the project as "the most complex weapon ever developed."[58] To illustrate this point, Table 7 provides a summary of all attempted HTK intercepts prior to the current systems, for which data will be provided later.

Table 7: Chronology of Exoatmospheric Hit-To-Kill Missile Tests

Experiment	Date	Status	Test Description and Results
HOE	Feb 83	Fail	Homing Overlay Experiment. Sensor cooling system failure.
HOE	May 83	Fail	Guidance Electronics Failure.
HOE	Dec 83	Fail	Software Error.
HOE	Jun 84	Pass	Demonstrated the feasibility of a missile achieving a direct hit against a small re-entry vehicle.
ERIS	Jan 91	Pass	Re-entry vehicle Interceptor System. Range 925 Km Alt 270 Km. Selected tgt between 2 decoys. V(c) 13.4 Km/sec
ERIS	Mar 91	Fail	Re-entry vehicle Interceptor System. Properly tracked, failed to complete intercept due to timing. Alt 290 km. V(c) 11.2 km/sec.

Source: Chronology of Hit-To-Kill Missile Tests[59]

While only a third of the intercepts were successful, it should also be noted that some of the failures were not the result of a failure of the technically demanding target acquisition, target discrimination or HTK maneuver unique to ABM systems.

The Ballistic Missile Defense Organization (BMDO)

> *We [BMDO] function as the 'integration systems architect' for an entire mission area – one that cuts across all the Services.*
>
> Lt Gen Lester L. Lyles, Director BMDO, 14 Apr 99 Testimony

The organization responsible for creating "the most complex weapon ever developed" is the Ballistic Missile Defense Organization (BMDO). BMDO was

[58] Bradley Graham, "Missile Shield Still Drawing Friends, Fire," *Washington Post*, 17 January 2000, Sec. A1.
[59] George Lewis, *Chronology of Hit-To-kill Missile Tests*, 6 April 1997, URL <http://www.fas.org/spp/eprint/lewis_tests.htm,> accessed 19 January 2000.

established in May 1993 and is the successor to the Strategic Defense Initiative Office created in April 1984 under President Reagan.

The mission of BMDO is:

> To manage, direct and execute the BMD program in order to achieve the following objectives: enable deployment of effective, rapidly relocatable Theater Missile Defense to protect forward deployed and expeditionary U.S. armed forces as well as friends and allies; develop options for, and deploy when directed, an antiballistic missile system to defend the U.S.; demonstrate advanced technologies to enhance initial BMD systems; and continue programs of basic and applied research to develop follow-on technologies.[60]

BMDO has prioritized its efforts in accordance with the four stated missions and each area is funded accordingly. Table 8 contains funding data by mission area (demonstrating advanced technologies, and applied research have been rolled up into the single category of Support Programs). The Heritage Foundation strongly disagrees with this emphasis and advocates that NMD should be the first priority.[61]

Table 8: BMDO Funding by Category

Year	NMD	TMD	Support Programs	Total
1985	647	22	748	1417
1986	1,048	22	1,606	2,676
1987	1,177	78	2,025	3,280
1988	1,423	125	2,005	3,553
1989	1,651	111	1,865	3,627
1990	1,583	131	1,857	3,571
1991	1,265	392	1,431	3,088
1992	1,916	822	1,194	3,932
1993	1,886	1,103	718	3,707
1994	553	1,646	529	2,728
1995	387	1,970	382	2,739
1996	729	2,234	381	3,344
1997	811	2,418	393	3,622
1998	942	2,293	425	3,660
1999	1,688	1,747	738	4,173

60 Department of Defense, *Directive 5134.9: Ballistic Missile Defense Organization*, 14 June 94. URL <http://web7.whs.osd.mil/text/d51349p.txt> accessed 12 April 2000.
61 Heritage Foundation, *A Near and Long Term Plan to Deploy Missile Defenses*, 27; Heritage Foundation, *Ending America's Vulnerability to Ballistic Missiles*, 35.

2000	965	2,072	769	3,806
2001	1,916	1,721	854	4,491
Total	**20,587**	**18,907**	**17,920**	**57,414**

Source: BMDO

Configuration of the Proposed Land-Based System

> *The structure of the theater and National Missile Defense (NMD) programs meets present and projected future missile threats, provides the best technology to meet these threats, and is fiscally prudent.*
>
> William S. Cohen,
> Annual Report to the President and Congress, 2000[62]

The proposed land-based system would be phased in with each new phase giving the system an increased number of interceptors and expanding the overall capabilities of the system. The system was originally developed to three capability levels, C-1 to C-3. If the system is deployed, it is likely that the initial fielding will be a "C-1 prime" version, which possesses the same capabilities as the original C-1 version but with an increased number of interceptors.[63] All of the configurations are comprised of the same four basic elements, a Ground-Based Interceptor (GBI), a ground based radar system comprised of Upgraded Early Warning Radars (UEWR) and X-Band Radars (XBR), space-based sensors, and a Ballistic Missile Command Control and Communications system (BM/C3). Some of these elements will be entirely new and other elements are modifications, improvements or extensions of earlier BMD, early warning, or command and control systems. A number of these elements would also be required for the sea-based system. Table 9 contains a list of all of the land-based NMD components and their locations for the various capability levels.

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[62] Cohen, *Annual Report to the President and the Congress*, 69.
[63] Daniel G. Dupont, "Administration Plans $2.2 Billion Increase for Expanded NMD Program," *Inside The Air Force,* 17 December 1999, 1.

Table 9: Notional Deployment Architectures

Architecture	C1	C1 Prime*	C2	C3
IOC	2003 to 2005	2005-2007 (1)	2010	2015
GBI	20 Based in Alaska	100 Based in Alaska	80-100 Based in Alaska	125 Based in Alaska 125 in Grand Forks
UEWR*	Beale, Clear, Cape Cod, Flyingdales, Thule	Beale, Clear, Cape Cod, Flyingdales, Thule	Beale, Clear, Cape Cod, Flyingdales, Thule	Beale, Clear, Cape Cod, Flyingdales, Thule, South Korea
XBR	Shemya	Shemya	Shemya, Clear, Flyingdales, Thule	Shemya, Clear, Flyingdales, Thule, Beale, Cape Cod, Grand Forks, Hawaii, South Korea
Space Sensors	DSP, SBIRS-High	DSP, SBIRS-High	DSP, SBIRS-High, SBIRS-Low	SBIRS-High, SBIRS-Low
IFICS	Shemya AK, Caribou ME	Shemya AK, Caribou ME	Central AK, Shemya AK, Caribou ME, Munsing MI	Central AK, Shemya AK, Caribou ME, Munsing MI, HI
BMC3	Cheyenne MTN OPS Center, ARCCC, Node at Weapons Site	Cheyenne MTN OPS Center, ARCCC, Node at Weapons Site	Cheyenne MTN OPS Center, ARCCC, Node at Weapons Site	Cheyenne MTN OPS Center, ARCCC, Node at Weapons Site
Threat	Simple penetration aids	Simple penetration aids	Sophisticated penetration aids	SLBM

Source: Various

Ground-Based Interceptors (GBI)

The ground-based interceptor has three basic components. The most technologically difficult of these three components is known as the Exoatmospheric Kill Vehicle (EKV). The EKV, which began development in 1993, is a HTK interceptor that has its own multiple wave-band infrared seeker, propulsion system, communications system, and guidance and control system computers with discrimination algorithms to support target selection and intercept decisions. The EKV also uses up-linked transmissions from the ground-based command and control center.

The second component is the booster, which delivers the separating EKV to a specific acquisition point and on a precise trajectory above the earth's atmosphere en route to engage the reentry vehicle. The GBI will be a silo based three-stage rocket. Three options were considered for the GBI booster, a Minuteman III ICBM, an entirely

new rocket, or a commercial off-the-shelf solid rocket booster system, which was the option eventually selected.[64] Flight-testing of the booster is scheduled to begin in FY01. The first Integrated Flight Test (IFT) of the NMD system using the actual rocket booster will be IFT-7 in FY03.

The third component of the GBI consists of the ground-based command and launch equipment necessary to house, protect and launch the interceptor missile. The deployed version of the GBI will be sealed in canisters and loaded in the underground silos where they can be stored for up to 10 years.[65]

Table 10 summarizes the integrated flight test (IFT) program of which the first four tests have been conducted. In addition to the IFTs, a series of Integrated Ground Tests (IGTs) will be conducted. To a great extent these IGTs utilize actual NMD hardware and software. A significant benefit of this type of testing is that, "Unlike range constrained IFTs, IGTs will test the total engagement space in a tactical environment."[66]

Table 10: Land-Based NMD System Integrated Flight-Testing

Test	Date	Status	Remarks
IFT 1	01-Jan-97		Payload Launch Vehicle failed. Test aborted.
IFT 1A	23-Jun-97	Pass	Sensor Flight Test. Sensor technology and performance. Non-intercept fly by test designed to assess EKV seeker discrimination and homing algorithm. Boeing EKV.
IFT 2	16-Jan-98	Pass	Sensor Flight Test. Sensor technology and performance. Non-intercept fly by test designed to assess EKV seeker discrimination and homing algorithm. Raytheon EKV.

[64] Federation of American Scientists, "Ground Based Interceptor," downloaded from www.fas.org/spp/starwars/program/gbi.htm, 1 Dec 1999. Department of Defense, "National Missile Defense Interceptor Booster Selected," OASD News Release 27 July 98, URL <www.defenselink.mil/news/jul1998/b07271998_bt398-98.html> accessed 15 November 1998. In July 1998 Boeing won the contract to assemble the booster stack, comprised of an Alliant Tech Systems GEM-VN motor for the first stage, and United Technologies Orbus-1 motors for the second and third stages. The booster alone is estimated to cost $3 million a copy.

[65] Northrup Grumman, "National Missile Defense Canister System Successfully Completes Development Test Milestone," Press Release (Baltimore, MD), 16 Aug 99.

[66] Department of Defense, Director of Operational Testing and Evaluation, *DOT&E FY98 Annual Report to Congress*, February 1998 (Washington, DC), 3, URL < www.dote.osd.mil/reports/FY98/98tocmain.html> accessed on 7 July 1999.

IFT 3	02-Oct-99	Pass	EKV intercept flight testing. Evaluate discrimination and intercept of RVs by kill vehicles. First attempt at intercepting a threat representative ICBM target. Target launched from Vandenburg. Interceptor launched from Meck Island, Kwajalein Atoll. 4200 mile test. IFT 3 and IFT 4 were supposed to use Boeing and Raytheon EKV's. Decision to down select to one EKV prior to test 3. Raytheon EKV selected. DSP satellites, GBR at Kwajalein, upgraded early warning radar at Beale AFB, Calif., and BM/C3 in "shadow" mode—actively viewing and computing but not controlling the intercept. Target cluster included the RV and a single decoy balloon. Simulated radar track date provided by GPS receiver on target and C-band radar beacon.
IFT 4	18-Jan-00	Fail	EKV intercept flight-testing. Evaluate discrimination and intercept of RVs by kill vehicles. All components except DSP and IFICS, which are still in "shadow mode." Same decoy as IFT-3. Failed to intercept due to a IR seeker cooling system problem. All other systems appeared to operate correctly.
IFT 5	26 Jun-00		First integrated system test. Will evaluate NMD system performance. System alerted by DSP. IFICS will transmit data. Same target set as IFT 4.
IFT 6	Jul-00		Repeat of IFT 5. Same target set as IFT 4 and 5.
IFT 7	2Q FY01		First test with actual booster; all previous tests use Minuteman III "payload Launch Vehicle." Countermeasures sophistication increased to a "more complex rogue threat" that is still C-1 type.
IFT 8	3Q FY01		All tests through IFT-7 use rogue nation type countermeasures.
IFT 9	4Q FY01		
IFT 10	1Q FY02		
IFT 11	2Q FY02		
IFT 12	3Q FY02		
IFT 13	1Q FY03		Operational EKV
IFT 14-21	3Q FY03 to FY05		Complete EMD and produce prime system components. Complete IOT&E
			3 Booster verification tests planned Mar 2000-2001

Source: Various

For four tests conducted the threat target complex was launched aboard the Multi-Service Launch System (MSLS), a specially configured three-stage Minuteman II ICBM. In lieu of the actual booster, a Payload Launch Vehicle (PLV) -- a refurbished two-stage Minuteman II -- was used to boost the EKV.[67] The first two flight tests, both of which were successful, were fly-by only tests to demonstrate sensor performance. The first fly-by test was conducted using a Boeing designed EKV, and the second fly-by test was

[67] This is considered to be a significant risk area because the actual booster will induce significantly higher shock and acceleration loading on the EKV. *National Missile defense Review*, 29.

conducted using a Raytheon EKV.[68] The original test program called for a second flight test of each EKV, however a decision was made to select the EKV after the first round of testing. The Raytheon EKV was selected for use in the NMD program.[69]

The third IFT was the first in which the EKV was actually to attempt an intercept of the target. The target complex was launched from Vandenburg Air Force Base and the interceptor missile was launched 4300 miles away from Kwajalein Atoll in the Marshall Islands. This test was originally pronounced a total success, however recently some questions have been raised about the test results.[70]

The fourth IFT was similar to IFT-3 but the test integrated more elements of the NMD system such as the BMC3 system, XBR and cueing from Defense Support Program (DSP) satellites. While the EKV failed to intercept the target, due to a cooling system failure that rendered both IR sensors inoperable, all other elements of the NMD system appear to have worked.[71]

One more IFT is scheduled prior to the President's decision in June of this year on deployment of the NMD system. All of the elements used in this fifth test will be actual parts of the final NMD system, except the surrogate PLV instead of the actual booster will still launch the EKV. The Space-Based Infrared System (SBIRS), which will eventually be part of the NMD system, will also not be available for this test. However, the SBIRS is not required for or part of the proposed C-1 capability system.

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[68] Department of Defense, Ballistic Missile Defense Organization, *Ground Based Interceptor Sensor Flight Tests*, Fact Sheet, URL <www.acq.osd.mil/bmdo/bmdolink/pdf/jn9905.pdf> accessed on 18 March 2000.

[69] DOD, DOT&E, *DOT&E FY98 Annual Report to Congress*.

[70] During the 2 October test an incorrect star map had been loaded into the EKV forcing it to use its inertial guidance system, which developed some drift during the flight. The sensors on the EKV initially detected one of the decoys, a Mylar balloon, at the edge of its field of view and using that as a reference then found and destroyed the correct reentry vehicle. James Glanz, "Flaws Found In Missile Test That U.S. Saw As a Success," *New York Times*, 14 January 2000.

Ground-Based Radar

The ground-based radar network for the proposed land-based NMD system would include two types of ground-based radar systems. The first system is composed of five or six UEWRs. The second system would be a single XBR for the C-1 system and up to nine XBRs for the C-3 system. Radar locations were previously listed in Table 9.

The function of the UEWR is to detect, track and count the number of missiles in order to provide data to commit to a launch of NMD interceptors.[72] Deployment of the Space Based Infra-red System (SBIRS) discussed below would eliminate the need for the UEWRs. The principle upgrades to the five existing early warning radars would be software modifications to increase their range, sensitivity and accuracy. To date permission has not been received to update the Ballistic Missile Early Warning System (BMEWS) radar in Thule, Greenland, or Flyingdales, UK.[73]

The XBR is the primary fire control sensor, providing surveillance, acquisition, tracking, discrimination, fire control support and kill assessment for the proposed land-based system.[74] The advantage of additional forward deployed XBRs would be their ability to provide accurate, high-resolution data from the early phases of an ICBMs

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[71] Senior Defense Official, "National Missile Defense," background briefing, Washington, DC, 19 January 2000, URL <www.defenselink.mil/cgi-bin/dlprint> accessed on 18 January 2000.
[72] Currently FPS-115 PAVE PAWS (Phased Array Warning System) Radars are located at Cape Cod and Beale. Clear Air Station, AK was upgraded to a PAVE PAWS in 1998 with existing equipment from Robins AFB, GA and Eldorado AFS, TX. AN/FPS-120 Solid State Phased Array Radars are located in Thule, Greenland and Flyingdales, UK. Federation of American Scientists, "AN/FPS-115 PAVE PAWS Radar," URL <www.fas.org/spp/military/program/track/pavepaws.htm> accessed 1 December 1999; Federation of American Scientists, "AN/FPS-120 Solid State Phased-Array (SSPAR)," URL <www.fas.org/spp/military/program/track/clear.htm> accessed 1 December 1999.
[73] Even though these are U.S. owned radars and are part of the current early warning system, host nation approval would be required to expand their capabilities as part of the NMD system. Although permission has not yet been received the U.K. is considering approval, however they may make approval contingent upon expanding coverage of the NMD system to include the U.K. Douglas Barrie, "British Mull U.S. Request for Missile Defense Site," *Defense News*, 31 January 1999, 1; "Blair's Price: Protect Britain?," *Newsweek*, 7 February 2000.
[74] Federation of American Scientists, "Ground Base Radar (GBR) X-Band radar (XBR)," URL

trajectory. Earlier tracking data would allow earlier launch of interceptors. This would increase the area in which they could engage and would allow more time for kill assessment and reengagement if required. Work on a prototype XBR was begun on Kwajalein Atoll in 1994. It does not have the full number of transmit receive modules that the final versions of the radar will possess. The prototype XBR was used in "shadow mode" in IFT-3 and provided track data in IFT-4.[75] Initial indications are that it performed better than expected. The range of the XBRs would be 4-5000 km or approximately five times that of even very optimistic projections for enhanced SPY-1 radars, which are the primary sensor for the proposed sea-based NMD system. The NMD XBR is very similar to the Theater High Altitude Air Defense radar although greatly expanded and more capable. While both use identical transmit/receive modules the radar array for THAAD uses 25,344 modules while the NMD XBR will utilize 81,000 modules. The XBR prototype array at Kwajalein Atoll is populated with only 16,896 of the modules.[76]

Ballistic Missile Command, Control and Communications System (BM/C3)

The extraordinary complication of the BM/C3 system cannot be overstated. And as difficult an engineering problem as designing and building an interceptor capable of maneuvering to collide with a missile at over 15,000 km/hour is, the BM/C3 component

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<www.fas.org/spp/starwars/program/gbr.htm> accessed on 7 July 1999.

[75] 'Shadow mode' testing refers to operating a component of the NMD system during the test of another component of the NMD system and collecting data on the performance of the equipment not being tested. However the shadow mode equipment does not provide input to the test as it normally would in the final system nor is it a required element of the test. The functionality of the shadow mode components will not affect the overall outcome of the test being conducted. This practice has been commonly used throughout development of the NMD system and is a way of maximizing the value of each tremendously expensive test without unnecessarily jeopardizing the evaluation of the elements being tested.

[76] Stanley W. Kandebo, "NMD System Integrates New and Updated Components," *Aviation Week & Space Technology*, 3 March 1997, 48; "USA/Ground Based Interceptor (EKV)," *Jane's Defensive Weapons Systems*, Vol. 30, 21 May 1999.

"has been identified as one of the most difficult issues associated with an NMD system."[77] The purpose of the NMD BM/C3 system is to provide "the capability for the designated operational commander to plan, coordinate, direct, and control NMD weapons and sensors."[78] In both the land-based and sea-based NMD systems, the BM/C3 system is probably the most critical, yet least discussed component.

> Although kill mechanisms are often given much attention, the problems associated with battle management are indeed formidable. For the layered defense to operate successfully it is essential that information concerning locating, tracking, aiming and kill, and if necessary repetition of this sequence be accomplished… In any case it has been estimated that approximately 10 million lines of computer code alone need be written for the battle management system.[79]

Key requirements of the BM/C3 system are to develop and coordinate battle plans, continuously monitor and assess the situation, and coordinate and direct the NMD response. In order to accomplish these tasks, the system must be able to rapidly receive cueing, send cueing, initiate tracks, perform system track fusion from multiple sensors, perform target discrimination, plan intercepts, commit weapons and perform system kill assessment. It must then repeat these steps to re-plan intercepts of targets not destroyed by the first set of interceptors.[80] All of these functions are performed in a time critical environment. Depending on launch location, all of the above actions would have to be

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[77] Department of Defense, Ballisitic Missile Defense Organization, "NMD Battle Managament/Command, Control, and Communications (BM/C3), URL <www.acq.osd.mil/bmdo/bmdolink/html/ccc.html> accessed 16 June 1999.
[78] DOD, BMDO, "NMD BM/C3."
[79] This quote was referring to the original SDI system required to provide a layered defense against thousands of missiles. Since that time computing capacity has grown exponentially and with the reduced system requirements the overall complexity of the code has certainly diminished, nonetheless the software for the BMC3 system remains and extremely complex undertaking. John A. Jungerman, *The Strategic Defense Initiative: A Primer and Critique*, (University of California Institute on Global Conflict and Cooperation 1988), 22-23.
[80] David Hughes, "Battle Management Critical For Theater-Level Defense," *Aviations Week & Space Technology*, 3 Mar 97, 43.

flawlessly completed in less than the 15-40 minutes time from when a launched vehicle broke through cloud cover until it impacted the U.S.

The BMC3 system is acknowledged to be primarily a software development and not a hardware engineering issue.[81] However, the complexities of the software will almost certainly require very fast computers and communications systems to process and pass vast amounts of data between the dispersed elements of the NMD system. All of this must be done with a secure system, immune from physical or cyber-attack. For the land-based system, fiber optics have been identified as the desired method of transmitting data throughout the ground-based components of the system. However, extensive radio frequency communications will also have to be maintained with dozens of space-based assets.

The NMD BM/C3 software is being developed using a “build-a-little, test a little” philosophy and is being released in increments. In March 1997 Increments 1 and 2 were released. Increment 3 was released in September 1997. Increment 4 was integrated at Kwajalein Atoll and operated in “shadow mode” for the second and third EKV tests. The first use of the BMC3 software not including the In-Flight Interceptor Communications System (IFICS) was in IFT-4. Increment 5 is scheduled to be available in FY2000 and will have full functionality plus all the internal and external interfaces needed to support the NMD initial capability.[82]

A sub-component of the BMC3 system, the IFICS, which communicates with the interceptors in-flight, will also be required. For the C-1 capability, two IFICS systems

[81] BMDO, “NMD Program, NMD BMC3,”
[82] Kandebo, 51; Senior Defense Official.

would be required, and for the C-3 capability, five IFICS systems would be utilized. Table 9 gives the locations of the required IFICS systems.

Space-Based Infrared System (SBIRS)

The SBIRS program, which is managed by the Air Force, will provide an effective transition from the Defense Support Program (DSP) to an improved system that provides much greater ballistic missile detection and tracking capability at both the national and theater levels.[83] SBIRS is comprised of two satellite sub-systems, SBIRS-High and SBIRS-Low, and a Ground Segment. The SBIRS will support four key intelligence and data requirements for an effective NMD system. These include: missile launch warning, missile tracking and cueing for missile defense, technical intelligence about the missiles, and overall battlefield characterization.[84]

The SBIRS-High is the component that replaces the current early warning function of the current Defense Support Program (DSP) satellites. The final configuration of the SBIRS-High constellation will include four satellites in geosynchronous earth orbit and two satellites in highly elliptical orbit. After a recent two-year slip, the first planned SBIRS-High launch will be in FY04.[85] The currently flying and scheduled to be launched DSP program satellites provide sufficient coverage during this delay, which appears to be a fiscal rather than a technical issue.[86] The early warning function performed by the

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[83] Department of Defense, United States Air Force, *1997 United States Air Force Issues Book: Space Based Infrared System*, URL <www.af.mil/lib/afissues/1997/app_b_18.html> accessed on 22 June 1999.
[84] Department of Defense, Director of Operational Testing and Evaluation, *DOT&E FY97 Annual Report to Congress*, February 1997 (Washington, DC), 3, URL <www.dote.osd.mil/reports/FY97/airforce/97sbirs.html> accessed on 30 November 1999.
[85] Warren Ferster, "U.S. Testing Office Delays SBIRS Satellite Contracts," *Defense News*, 12 July 1999, 4.
[86] William B. Scott, "Congress Rips SBIRS Cutbacks," *Aviation Week & Space Technology*, 29 March 1999, 37.

current DSP satellites and the follow on SBIRS-High satellites is equally important for either the proposed land- or sea-based systems.

SBIRS-Low is the successor to the Brilliant Eyes program, which Congress transferred from the Ballistic Missile Defense Organization to the Air Force in FY94.[87] SBIRS-Low will be able to continue tracking the warheads after all missile booster stages burn out and the warheads are deployed. This information provides the earliest possible trajectory estimate of sufficient quality to launch interceptors for a mid course intercept. By providing this over-the-horizon precision tracking data to the NMD system, the interceptors can be fired before the missiles come within range of ground-based radars at the defense site.[88] This capability is not required at the C-1 capability level of the proposed land-based system due to the network of UEWRs and the 4-5000km range of the XBR. However, the SBIRS-Low capability would be essential to the proposed sea-based system due to limitations of the Aegis radar**.**

Like the current constellation of GPS satellites, SBIRS-Low will require a constellation of 24 satellites to provide complete earth coverage. Launching of the SBIRS-Low constellation has also recently slipped two years from a first launch in FY04 to a first launch in FY06. Unlike the SBIRS-High delay, which was primarily a funding issue, there appear to be some technical hurdles yet to be overcome with the SBIRS-Low satellites.[89]

Prior to the recent schedule change, the plan was to launch the first six SBIRS-Low satellites over a three-year period from FY04-07. There was then to be a one-year delay

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[87] DOD, USAF, *1997 United States Air Force Issues Book: Space Based Infrared System.*
[88] Department of Defense, Ballistic Missile Defense Organization, “National Missile Defense Program Space and Missile Tracking System,” URL <www.acq.osd.mil/bmdo/bmdolink/html/sbir.html> accessed on 16 June 1999.

during which time the satellites' performance would be analyzed. Flexible design would then allow for modifications of the remaining satellites prior to their launch.[90] Extending this same launch plan with a first launch in FY06 means that a fully operational SBIRS constellation will not be in place until well after FY10. As long as the Aegis radar is the primary sensor for the proposed sea-based system, this lack of the SBIRS-Low capability will severely limit the system's effectiveness as an NMD system.

The SBIRS Ground Segment includes a CONUS based Mission Control Station (MCS), a MCS backup (MCSB) and Survivable MCS (SMCS) overseas relay ground station, Multi-Mission Mobile Processors (M3P), and associated communications links. Delivery of the SIBRS ground segment will be in three segments. Segment one consolidates both DSP and Attack and Launch Early Reporting to Theater (ALERT) ground stations into a single CONUS ground station. Segment Two adds the functions required for the SBIRS-high satellites. Finally, Segment Three integrates the functions necessary for the SBIRS-Low satellites.[91]

Sea-Based System Description

The United States Navy is currently embarked on programs to provide both lower and upper tier BMD. Both BMD programs will be achieved by incremental expansion of the combined capabilities of two existing systems, the Aegis Weapons System (AWS) and the SM-2 missile. The Navy Area Wide (NAW) system will provide lower tier

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[89] Scott, 37.

[90] DOD, DOT&E, *DOT&E FY99 Annual Report to Congress.*

[91] Prior to the two-year delay in fielding SBIRS High, which slipped from FY02 to FY04, and SBIRS-Low, which slipped from FY04 to FY06, the schedule for the SBIRS ground segment was for segment one to be operational in late FY99, segment two in FY02 and segment three in FY04. Segment one is now scheduled for FY00 and corresponding delays for the other segments are expected. Department of Defense, United States Air Force, Space and Missile Systems Center, *Space-Based Infrared System Handbook*, (Los Angeles, CA), 19, URL <www.laafb.af.mil/smc/mt/sbirs.htm> accessed on 26 March 2000.

defense against short- and medium-range TBMs, and the Navy Theater Wide (NTW) system will significantly increase the defended footprint of the NAW system and provide defense against long-range TBMs. While there are many factors required to determine the defended area, the NAW system is nominally capable of defending an area with a radius of 50-150 km (27-81 miles) and to an altitude of 30,000 m (100,000 ft). The NTW system would nominally provide defense against missiles beyond 150 km, above an altitude of 70,000m (220,000 ft).[92]

Aegis Weapon System

Over $50 billion dollars has been spent to develop and deploy the AWS on board 27 Ticonderoga class cruisers (CG 47-73).[93] Of the 27 Ticonderoga class cruisers, all except the first five (CG 47-51) are outfitted with two MK 41 Vertical Launch Systems (VLS).[94] Each of the forward and aft MK 41 VLS has 63 cells providing the ships with 126 missiles ready for launch at any given time. Missiles which can be fired from the MK 41 system and which must be allocated cells include SM-2 missiles in several variants, Tomahawk cruise missiles in several variants, the Vertical Launch Anti-Submarine Rocket (VLA) and eventually the Land Attack Standard Missile (LASM) and the SM-3.[95]

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[92] "RIM-66/67/156 Standard and Standard SM-LEAP/SM-3," *Jane's Strategic Weapons Systems*, Vol. 28, 7 Oct 98.

[93] Heritage Foundation, *A Plan to Meet the Urgent Missile Threat,* 2.

[94] Due to their limitations, compared to the later ships in the Ticonderoga class, the first five AWS Baseline I cruisers are not typically assigned to CVBGs or deployed as regularly as the remaining 22 ships in the class. It may be possible to convert these five ships to single mission NMD platforms, as a sea-based adjunct to a land-based NMD system, while having a limited impact upon the current overall mission requirements of the Aegis cruisers. P.M. Grant III, Director, Navy Theater Wide Program, PMS452, interviewed by author 23 February 2000. Also at the interview were Mr. Jeff Johnson and Mr. Stan Groenig.

[95] Richarde Sharpe, eds., *Jane's Fighting Ships,* (Surrey, UK: Jane's Information Group 1999),809.

Those cruisers without the MK 41 VLS will not be upgraded to become capable of firing the SM-3.[96]

The AWS is also deployed aboard 28 Arleigh Burke class (Flight I and II) guided missile destroyers and will be deployed on up to 18 additionally planned Arleigh Burke class (Flight IIA) guided missile destroyers. There are plans to upgrade the Arleigh Burke class destroyers to perform NAW BMD, however, there are not currently plans to upgrade the Arleigh Burke Destroyers to carry the SM-3 missile and conduct NTW BMD.

Navy Area Wide

Modifications to the AWS required for the NAW system include upgrading the AWS software, and improving the capabilities of the SPY-1 radar. The latest version of the AWS software at sea is Baseline 5 Phase III. Baseline 6 Phase III will add the missile tracking and engagement capability, but developmental problems with the software have already caused an 18-month slip of 10 DT/OT tests scheduled for FY99 and FY00.[97] The total cost for the NAW upgrades and 1500 SM2 Block IVA missiles is projected to be $6.710 billion and with no further delays, the system will be deployed in FY03.[98] The NAW testing and fielding schedule is contained in Table 11.

Table 11: NAW Fielding Schedule

[96] The first five Aegis cruisers designated baseline 1 are less capable than the remaining ships in the class and do not normally deploy with the CVBG's and have a much lower utilization. As yet another possibility for providing a sea-based adjunct to a land-based NMD system these five ships could be modified, upgraded and deployed as single mission NMD platforms. There is no official support, research or data supporting this concept. The idea surfaced during Grant, interview and demonstrates that there are many possible options for augmenting the land-based NMD system with sea-based systems. Ambassador Cooper is however opposed to a dedicated sea-based NMD system. Henry F. Cooper, former Director, The Strategic Defense Initiative Organization, interviewed by author 3 March 2000.
[97] "Navy Area Defense System: Interceptor Builds on Aegis Success," *Air Defense Artillery Magazine Online*. URL <http://www.147.71.210.21/adamag/navy.htm> accessed on 22 June 1999.
[98] DOD, DOT&E, *DOT&E FY99 Annual Report to Congress*.

Year	Activity
FY97	Milestone II: Engineering and Manufacturing Development
FY99-01	DT/OA at White Sands Missile Range. 8 Tests events.
FY01	LRIP
FY01	Linebacker At Sea Testing. 3 Test events.
FY02-03	DT/OT at Pacific Missile Test Range. 25 Test events. 16 TBM. 9.AAW
FY03	FUE
FY03	Milestone III: Production

Source: Navy Area TBMD Program Overview[99]

The problems NTW has experienced with integrating the TMD software highlight the difficulty and complexity of this issue, which can have a dramatic effect on system development and fielding. The code required for the AWS has already expanded from 820,000 lines of code in the Baseline 0 version to over 6.5 million lines of code in the most recent Baseline 5 Phase III.[100] With this ever increasingly complex operating system, it cannot be assumed that any further enhancements to the system will be easy or rapidly effected.

The critical need for a TBM capability and the NAW developmental delays has brought about an interim measure known as the "Linebacker" program. For the Linebacker program two cruisers, the U.S.S. Lake Erie and the U.S.S. Port Royal, are equipped with User Operational Evaluation System (UOES) software, which provides them with a TBMD capability. These ships are referred to as "or" ships, however, because the UOES only allows the ships to either use UOES to perform the TBMD mission or use the standard multi-mission Baseline 5 software to perform their normal missions. Reconfiguration between the two software loads can be done in less than a day.[101]

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[99] Jerry LaCamera, "Navy Area TBMD Overview," briefing presented to Potomac Institute, 4 May 1999.
[100] "RIM-66/67/156 Standard and Standard SM-LEAP/SM-3."
[101] "Navy Area Defense System: Interceptor Builds on Aegis Success," URL <147.71.210.21/adamag/navy.htm> accessed on 22 June 1999.

AN/SPY-1 Radar

As part of the TBM upgrades, the capabilities of the SPY-1 radar are being increased. Actual capabilities, current and future, are classified however a range of at least 300 km will be achieved for NAW, and further increases out to 500 km for the NTW system are also believed achievable by that timeframe.[102] There is speculation that the radar performance could be increased to nearly 1000 km, which provides a significant capability against TBMs but would still be insufficient for many NMD applications. As part of the future upgrades to the system contracts have been signed for studies of both an AN/SPY-1 Solid State Upgrade using S or S/C Band and a TBMD Adjunct Radar using X Band, the later radar concept being very similar to the THAAD Radar.[103]

SM-2 Standard Missile

The SM-2 surface-to-air missile was introduced in the 1960s and has been subject to 30 years of incremental improvements to its current configuration.[104] The latest version is the SM-2 Block IVA which has improved capabilities against low-flying cruise missiles as well as an endoatmospheric (under 40,000 m) ballistic missile capability. Due to its multi-mission capability, the SM-2 Block IVA uses a dual mode IR/semi-active radar seeker and high explosive warhead to engage and destroy the target. All other ABM programs in the United States use a HTK warhead. The first successful test of the SM-2 Block IVA against a ballistic missile occurred 27 January 1997 at the White Sands Missile Range. A complete testing schedule is contained in Appendix B. The SM-2

[102] "RIM-66/67/156 Standard and Standard SM-LEAP/SM-3."
[103] P. M. Grant, III, *Navy Theater Wide Program Brief*.
[104] "RIM-66/67/156 Standard and Standard SM-LEAP/SM-3."

Block IVA is currently in the EMD phase with full rate production scheduled to begin in FY03.[105] Approximately 1500 SM-2 Block IV and IVA missiles will be built.

SM-3 Standard Missile/LEAP

The next version of the standard missiles will be the SM-3 Block I. An increased capability SM-3 Block II is also envisioned but has yet to be programmed for. The SM-3 will be capable of exoatmospheric intercepts (at altitudes greater than 70,000 m). It is at the SM-3 Block II level that a sea-based system would begin to possess an NMD capability. As currently planned the SM-3 is identical to the SM-2 Block IVA except the warhead is replaced with an advanced axial third stage motor which will provide a V(bo) of 3-3.5 km/sec for the Block I missiles and perhaps as high as 4-4.5 km/sec for the Block II missiles and the Lightweight Exoatmospheric Projectile (LEAP) kill vehicle. Removing the 115 kg warhead allows for the third stage rocket motor and 23 kg LEAP.[106]

Work on LEAP started in 1985 as part of the SDIO space-based interceptor program, but was moved to consideration as a ground-based interceptor either for the NMD program or in conjunction with the SM-2 missile in 1992.[107] According to Hughes Missile Systems, the LEAP performed well during the Navy LEAP technology demonstration program. Although none of its four in-space tests was successful, Hughes claims that during FTV-3 and FTV-4 the LEAP accomplished 42 of 43 test objectives.[108]

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[105] Jerry LaCamera, "Navy Area TBMD Overview," briefing presented to Potomac Institute, 4 May 1999.
[106] "RIM-66/67/156 Standard and Standard SM-LEAP/SM-3"
[107] "RIM-66/67/156 Standard and Standard SM-LEAP/SM-3."
[108] "RIM-66/67/156 Standard and Standard SM-LEAP/SM-3"

But the bottom line is that in these intercept tests the LEAP failed to complete the intercept.[109] Table 12 contains a summary of LEAP testing.

Table 12: LEAP Testing

Test	Date	Status	Remarks
Hover Test	18-Jun-91	Pass	Non-Intercept. Hover and tracking test of Hughes LEAP
Hover Test	31 Jun 91	Pass	Non-Intercept. Hover and tracking test of Rockwell Boeing LEAP
LEAP 1	18-Feb-92	Pass	Lightweight Exoatmospheric Interceptor. Non-Intercept Test, however interceptor passed within 418 m of the target.
LEAP 2	19-Jun-92	Fail	Failed to receive target position and speed data.
LEAP 3	Jun-93	Fail	Missed target by 7 m.
LEAP 4-8	CANX		
FTV-1 LEAP	24-Sep-92	Pass	Non-Intercept. Functional Technology Validation or Flight Test Vehicle. A modified Terrier missile was fired from the USS Richmond S. Turner to test the high altitude aerodynamics of the missile. No LEAP interceptor was on the missile.
FTV-2 LEAP	1-Sep-93	Pass	Non-Intercept. SM-2 Block 3 interceptor launched from the USS Jouett. Simulated LEAP interceptor deployed by missile.
FTV-3 LEAP	4-Mar-95	Fail	Launched from USS Turner. Hughes KV aboard a Standard Missile. Seeker able to track but missile went off course due to second stage guidance error.
FTV-4 LEAP	28-Mar-95	Fail	Launched from USS Turner. Rocketdyne KV aboard a Standard Missile. KV lost power after separation.

Source: Various

Following the string of test failures in 1996 BMDO conducted a "Blue Ribbon Review" to "review the options and recommend the preferred approach to continue development of the maturing Navy LEAP technology."[110] The review focused on three options and selected the current configuration, AEGIS LEAP, as the least risky. The Report to Congress with that recommendation also contained a TBMD Cost and Operational Effectiveness Analysis and Ballistic Missile Defense Program review in which it assessed AEGIS LEAP had "potential for entry into Engineering and

[109] Hughes Missile Systems Company, "Navy Leap Program Demonstrates Feasibility of Navy Theater-Wide TBMD," Fact Sheet, 1995, URL <www.fas.org/spp/starwars/docops/leap_test.htm> accessed on 19 January 2000.
[110] Department of Defense, *Report to the Congress on Navy Theater Wide Defense System (Formerly Navy Upper Tier)*, 1996, URL <www.fas.org/spp/starwars/program/ntwd_960325.htm> accessed on 1 December 1999.

Manufacturing Development (EMD) in the 2001-2002 timeframe." This assessment was made for only a TBM capable interceptor, not a NMD capable interceptor.

Navy Theater Wide

The current plan calls for phasing in the NTW Block I system in three stages, with a contingency capability being available in FY06 and four cruisers and 80 missiles available in 2010. Eventually it is planned to purchase 650 missiles, which could be carried by the 22 latest Aegis cruisers. The Block II capability will not be available until some time after 2010 and will most likely require a new radar, a significantly faster missile, more advanced sensors and greater divert propulsion. Table 13 contains the current NTW timeline, and a full testing schedule is contained in Appendix B.

Table 13: NTW Fielding Schedule

Year	Activity
FY99-01	Aegis Leap Intercept Testing (ALI) (DT-1A): 9 Test events.
FY03	(DT-1B): 3 Test events.
FY04	Milestone II: Engineering and Manufacturing Development
FY06	Block IA Contingency Capability.
FY08	Block IB Single Mission Capability (2 ships 50 missiles)
FY06-07	DT/OT. 20 Test events.
FY07	Milestone III: Production
FY10	Block IC Multi Mission Capability
TBD	Block II. Initial NMD Capability

Source: Navy Theater Wide Program[111]

Other Ballistic Missile Defense Systems

In addition to the ongoing land-based NMD program and the proposals for expanding the Navy's Theater Wide program to provide NMD, there are several other weapons systems capable of providing or assisting with NMD. These include airborne lasers, space-based lasers and space-based interceptors. Eventual development and

deployment of any of these systems could augment either a land or sea-based NMD system so their specific capabilities do not materially affect the current comparison.

Several sea-based concepts for NMD have emerged other than expanding the Aegis system to provide NMD. There is no significant development or support for these concepts yet and they are not being factored into the analysis contained in this paper. Nonetheless these other proposals have some merit and would have to be weighed if a sea-based alternative to the proposed land-based system was seriously considered.

The first concept proposes taking advantage of the four Trident submarines to be decommissioned in the next several years and the existence of over 400 retired Trident C-1 missiles. It is envisioned that with the capabilities of the C-1 missile, limited NMD could be obtained by keeping one of these submarines stationed off each coast. Due to the size and lifting capability of the C-1 missile, each missile could boost as many as 10 interceptors each having a higher V(bo) and longer range than the SM-3/LEAP interceptor.

The second concept proposes that instead of using the tremendously expensive multi-mission Aegis cruisers to launch SM-3 interceptors, the missiles could be launched from relatively inexpensive, NMD-dedicated barge-type craft. The proposed NMD sensors would provide cueing for the interceptors, and missile guidance would be provided by THAAD type radar on a separate barge-type vessel. The THAAD radar is more capable than the SPY-1 and this would take advantage of the fact that not collocating the sensors and shooters can produce a more efficient and effective defense. This would also ease many of the concept of operation and chain of command issues that will encumber the

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[111] Grant, *Navy Theater Wide Program Brief*.

use of Aegis cruisers for this role. Table 14 contains a summary of the capabilities of the various sea-based options.

Table 14: Sea-based NMD Options

Configuration	Platform	Interceptor	Acquisition	Fire Control	Kinematic Limitations
Modified NTW	Aegis	NTW Kill Vehicle with enhanced Standard Missile Kick Stage	DSP/SBIRS-High, Upgraded SPY, Sea Based GBR	Radar Cued by SBIRS	NTW 2800lb booster: Downrange 1700km, Alt 850km, V(bo) 4 km/s
Hybrid Sea Based System	Special Ship (Container Ship, Barge etc.)	NTW or GBI or THAAD	DSP/SBIRS-High, Sea Based GBR	GBR Cued by SBIRS	
Trident Based NMD	Trident	Trident C-4, 2-8 kill vehicles (NTW or THAAD or GBI) plus precursor to identify decoys.	DSP/SBIRS-High, SBIRS-Low	Intercept on SBIRS-Low	Trident 75000lb booster: Downrange 5200km, Alt 2500km, V(bo) 6 km/s

Source: Navy Based Missile Defense[112]

[112] M. Gantz, *Navy Based National Missile Defense*, Brief presented by Draper Laboratory, 4 March 1999.

Chapter 5

Sea-Based National Missile Defense: The Heritage Foundation Position

> *Continuously on station, effective missile defenses are needed worldwide to counter the missiles' potential for blackmail, terror, destruction, and disruption of U.S. military operations overseas. Without a ready response to such threats, the U.S. and its allies and friends will be subject to coercion and attack by otherwise third-rate powers armed with missiles and weapons of mass destruction.*
>
> *Defending America: A Near- and Long-Term Plan to Deploy Missile Defenses*

The Heritage Foundation is a conservative think tank that has traditionally promoted a strong national defense.[113] In keeping with this stated goal The Heritage Foundation has been a strong advocate of NMD for several decades and has more recently become one of the leading advocates for sea-based NMD. In addition to numerous papers and memoranda on the issue, The Heritage Foundation has released three comprehensive publications starting in 1995 with *Defending America: A Near and Long Term Plan to Deploy Missile Defenses*, followed by *Defending America: Ending America's Vulnerability to Ballistic Missiles* in 1996, and finally, *Defending America: A Plan to Meet the Urgent Missile Threat* in 1999. These three publications provide the basis for the proposed sea-based NMD plan against which the current land-based plan will be assessed.

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[113] From the Heritage Foundation Mission Statement. Heritage Foundation, *A Plan to Meet the Urgent Missile Threat*, inside cover.

The 1995 and 1996 reports were prepared by the Team B Study Group, which was renamed The Heritage Foundation's Commission on Missile Defense for the 1999 report. In all cases the individuals involved in the reports have extensive backgrounds and expertise in NMD programs, technology and capabilities, as well as the political and foreign policy issues relating to NMD. A list of the members and their qualifications is contained in Appendix C.

The recommendations of The Heritage Foundation are strongly endorsed by High Frontier, another organization with a long history as an advocate of NMD. In fact it is largely the work of High Frontier under the direction of Lt. Gen. Daniel O. Graham in the late 1970s and early 1980s that convinced President Reagan that a NMD system was technically possible and strategically desirable.[114] However, this endorsement of the Heritage platform is to be expected since Ambassador Cooper, the current Chairman of the Board of High Frontier, served as Chairman of The Heritage Foundation's missile defense commission for all three reports. Another institution that supports the Heritage position is The Center for Security Policy, chaired by Frank Gaffney, formerly Assistant Secretary of Defense for Security Policy.

The format and content of all three Heritage publications is very similar. Each issue, statement and recommendation in *Defending America: A Near and Long Term Plan to Deploy Missile Defenses* relevant to the merits of sea-based NMD will be addressed. Only those issues in the later reports that are new or different from the original report will be specifically highlighted. Additionally, even within each individual report the

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[114] Henry F. Cooper, "Unfinished Business, Ambassador," URL
<www.highfrontier.org/UnfinshedBusiness.htm> accessed on 4 January 2000.

recommendations tend to overlap so it will be attempted to extract only the key, unique element of each recommendation for review.

Some of the following discussion will be very critical of the report's analysis and claims about sea-based NMD. However, there are several other issues contained in these reports which are extremely good. For example, the report released in 1995 took issue with the ballistic missile threat assessment released that year by the CIA in NIE 95-19, *Emerging Missile Threats to North America*. The Heritage Foundation's threat was probably much more realistic than the CIA's and was recently validated by *The Report of the Commission to Assess the Ballistic Missile Threat to the United States* also known as the Rumsfeld Commission Report released in July 1998. *Defending America* also contains a superb discussion of ABM treaty issues.

Recommendations of The Heritage Foundation 1995

• 1995-1. Heritage Foundation Recommendation: "*Deploy global defenses as soon as technically feasible--first at sea and then in space. Specifically, a decision should be made now to deploy as soon as technically feasible the Navy's Upper Tier interceptor system and the Brilliant Eyes space based sensor system.*"

The key element of this recommendation is the question of technical feasibility. Unquestionably the NTW system has not been fielded as fast as technically feasible. There have been both political and fiscal constraints on the development of the system. In 1995, at the time this report was released, utilizing the developing NTW system for NMD was certainly a novel and possibly viable option. Testing of the Aegis LEAP was ongoing and probably on par with the land-based NMD system, which was still classified as a Technology Readiness Program. The NMD program was not upgraded to a Deployment Readiness Program until FY96. According to official estimates at the time,

the NTW system was projected to enter EMD in 2001-2002.[115] The Heritage Foundation's proposal was much more aggressive, estimating a limited one-ship capability by 1998 and a full 22-ship capability by 2002.[116]

Obviously neither of these timelines has been met and without making an assessment of what could have been had funding and politics not played a role, but looking at what has transpired, with a current schedule to enter EMD in FY04 even the Navy's schedule appears to have been optimistic. The current schedule also calls for a phased approach to NTW with a contingency capability in FY06. This is however what is planned and not what is technically feasible. The Heritage Foundation's latest report concluded the technically feasible answer for full deployment was 3-4 years, which from the time of that report, March 1999, would have put the system at sea in FY02-03.[117] Ambassador Cooper remains firmly convinced that four years is the maximum amount of time it should take to deploy the system.[118]

The Navy Theater Wide Program office is somewhat more conservative but speculates that in an environment constrained only by technology, in six years it may be possible to deploy the NTW system. It must be considered however that unless in these short time periods a developmental leap is made directly to the Block II system, there still is no NMD capability and BMDO estimates it will take four years to go from Block I to Block 11.[119] BMDO's *Report to Congress on the Utility of Sea-Based Assets to National Missile Defense* does not evaluate the NTW Block I system as being able to contribute to NMD and assesses that "without upgrades the NTW Block II system would have no

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[115] DOD, *Report to the Congress on Navy Theater Wide Defense System*, 6.
[116] Heritage Foundation, *A Near- and Long-Term Plan to Deploy Missile Defenses*, 34.
[117] Heritage Foundation, *A Plan to Meet the Urgent Missile Threat*, 50.
[118] Cooper, interview.

useful capability against ICBMs or SLBMs."[120] For unsophisticated rogue nation threats this is due primarily to sensor limitations and the report states, "The AEGIS AN/SPY-1B radar is not capable of supporting NMD type engagements due to limited detection and tracking ranges for strategic (long-range) ballistic missiles and their reentry vehicles."[121] For more sophisticated threats it is also limited by interceptor velocity, tracking capability, divert capability, and kill vehicle hardening.[122] A summary of NTW capabilities is contained in Table 15.

Table 15: NTW NMD Capabilities

Interceptor	Sensor	NMD Utility Against Limited Attacks
NTW Block II	Organic Radar*	-None against ICBMs/SLBMs -Defend Coastal Cities against Threats of TBM to Intermediate Range
NTW Block II	NMD Sensors*	-Defend U.S. against Unsophisticated ICBM, SLBM Attack by Rest of World Threat.
Upgraded NTW Block II	NMD Sensors* SBIRS-Low	-Defend U.S. Against Sophisticated Ballistic Missiles
*NMD Sensor: Upgraded Early Warning radar, Forward Based Radars and/or Sbirs-Low		

Source: *Summary of Report to Congress on Utility of Sea-Based Assets to National Missile Defense*

Brilliant Eyes is a key component to the proposed sea-based NMD and the speed with which this system is technically capable of being fielded had to be questionable at the time of The Heritage Foundation's first report and remains so today. The Brilliant Eyes program is a legacy of the Reagan era SDI program and has evolved into the SBIRS-Low Space and Missile Tracking System (SMTS) component of the overall SBIRS program. The Capstone Requirements document for the SBIRS system, of which SBIRS-Low is probably the most difficult of the three components, was not approved by

[119] DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense, 4.*
[120] DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense, 3.*
[121] DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense, 10.*
[122] DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense, 11-12.*

the JROC until December 1994.[123] The initial SBIRS-Low program based on a fielding decision in the year 2000 would have had a first launch in 2006. This date was advanced to 2004 but has recently slipped back to a first launch in FY06.[124] The Director of Operational Testing and Evaluation noted in his FY97 report that there were "significant technical risks associated with the accelerated deployment of the low component by FY04," and in his FY98 report referred to the "continuing significant technical problems with the SBIRS Low PDRR satellites."[125] In the latest DOT&E report, even with the two-year slip in the program, six specific "significant technical challenges" are listed.[126] As with the NTW system it is impossible to determine what impact funding and politics have had on this system. There has been significant criticism of the Air Force's handling of this program and though the delays are stated to be due to technical issues, there are questions over the funding and priority this program is being given.[127]

• <u>1995-2</u>. Heritage Foundation Recommendation: "*Build Navy Upper Tier defenses*."

The Navy has continued with the development of the NTW system since 1992 albeit not necessarily at a steady nor optimal pace. The Navy plans on purchasing 650 SM-3 missiles and, as shown previously in Table 13, over the next ten years a comprehensive NTW system will be phased in aboard all 22 Aegis cruisers. This schedule is however ten years behind what was originally proposed in this first report and still will not provide

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[123] Federation of American Scientists, "Space Based Infrared System," URL <www.fas.org/spp/military/program/warning/sbir.htm> accessed on 19 February 2000.
[124] Federation of American Scientists, "Space Based Infrared System," URL <www.fas.org/spp/military/program/warning/smts.htm> accessed on 19 February 2000.
[125] DOD, DOT&E, *DOT&E FY97 Annual Report to Congress*; Department of Defense, Director of Operational Testing and Evaluation, "DOT&E FY96 Annual Report to Congress," Washington, DC, February 1996, URL <www.dote.osd.mil/reports/FY96/96sbirs.html> accessed 30 March 2000.
[126] DOD, DOT&E, *DOT&E FY99 Annual Report to Congress*, V-165.
[127] Gigi Whitley, "After Months of Debate, Pentagon Tells Congress of New SBIRS Plans," *Inside the Air Force*, 13 August 1999. Scott. Baker Spring of the Heritage Foundation would recommend either BMDO or the Navy take control of this program and put it on the same fast track development plan that would be

the NMD capability envisioned by The Heritage Foundation due to limitations of the SM-3 Block I missile and the SPY-1 radar and the lack of integration with SBIRS-Low.

• 1995-3. Heritage Foundation Recommendation: "*Expedite Brilliant Eyes*."

While expediting Brilliant Eyes a.k.a. SBIRS-Low is necessary in order to make the sea-based NMD system functional, the possibility of accelerating the SBIRS-Low program to meet the initial operating status goal of 2001 specified in this report was never realistic. With an additional five years of development since this report, this program continues to have serious technical challenges to overcome, and any significant advancement of the schedule is unlikely. Also, as the current fielding schedule is in-line with the fielding of the SM-3 Block I missile and well ahead of any planned deployment of the Block II missile, there is little reason to rush SBIRS-Low based on a sea-based NMD concept.

One issue somewhat neglected in The Heritage Foundation's discussion is the command control and communications (C3) linkage between SBIRS-Low and the AWS. The most direct method would be for the satellites to provide cueing directly to the ships in the same manner as the current Joint Tactical Ground Station (JTAGS) receives data directly from DSP satellites. While this is certainly technologically possible, it would pose some software and systems integration problems that could take years to solve as has been the case with upgrading the AWS to a TBM capable system. It would also represent a shift in the philosophy of the current BM/C3 system which is designed to centrally collect and process sensor data, perform intercept calculations, and make weapons assignments. The other option would be for the Aegis cruisers to receive

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required to accelerate the SM-3 to put it on a competitive timeline with the proposed land-based NMD system. Baker Spring, interviewed by author, 30 December 1999.

processed data and engagement orders from the central BM/C3 system as is currently envisioned for the land-based interceptor site.

Whichever option is chosen, integrating the AWS is an achievable task but it will take time, and very little effort is currently being expended in this area. This may in part be due to the ABM treaty, which under the strict interpretation would almost certainly not permit this. It is too late to get an early start on the integration issue. If sea-based assets are ever going to play any role in NMD, this issue should have been addressed back in 1995 when this report came out and the requirements for the BM/C3 system were still being developed.

• 1995-4. Heritage Foundation Recommendation: "*Fully fund Navy Upper Tier and Brilliant Eyes programs without ABM Treaty restraints*."

Table 16 provides The Heritage Foundation's recommended funding from each of the three reports versus the actual and future year proposed budgets for the NTW system. This table clearly demonstrates a gross underestimation by Heritage of both the cost and the time required to deploy the sea-based missile system. An exact comparison is difficult due to a lack of Heritage Foundation figures for the out years. However, by comparing the NTW Program office estimate and The Heritage Foundation's 1999 estimate for fielding a system by FY02, the discrepancy becomes evident. The official estimate projects it will cost $6.5 billion through 2011 at which point 80 SM-3 Block I missiles, without a NMD capability, will be deployed on four fully upgraded multi-mission Aegis cruisers. The Heritage Foundation claims 650 interceptors could be deployed on 22 cruisers in 2002 or 2003 for half that amount, $3.3 billion.[128]

[128] Heritage Foundation, *A Plan to Meet the Urgent Missile Threat*, 2, 50-51.

Table 16: Comparison of NTW Funding

($millions)

	NTW	Heritage Foundation Recommendations				
	Budget	1995 Report	1996 Report	1999 Report		
System Deployed	2006-10	1998 (1)	2000	2008	2005	2002
1995	75	75 (1)	75 (1)	75 (1)	75 (1)	75 (1)
1996	200	300	300	200 (1)	200 (1)	200 (1)
1997	304	360	360	304 (1)	304 (1)	304 (1)
1998	438	470	470	438 (1)	438 (1)	438 (1)
1999	364	450	450	190	325	441
2000	376	450	450	186	351	400
2001	383		450	183	307	389
2002	290 (2)			139	433	555
2003	455 (2)			144	597	472
2004	595 (2)					
2005	928 (2)					
2006	759 (2)					
2007	688 (2)					
2008	283 (2)					
2009	208 (2)					
2010	103 (2)					
2011	59 (2)					
Total	**6,508**	**2,105**	**2,555**	**1,859**	**3,030**	**3,274**

(1) Amount taken from actual spending and not reflected in Heritage Foundation report.
(2) Funding required to remain on the schedule outlined in Table 13.[129]
Source: Various

As with the NTW system it is difficult to determine the actual extent of the funding discrepancy between what is actually being spent on SBIRS-Low and what The Heritage Foundation recommends due to incomplete Heritage Foundation data. It appears that once more the overall funding is underestimated by over 50 percent as demonstrated by Table 17.

[129] Grant, *Navy Theater Wide Program Brief*.

Table 17: Comparison of SBIRS-Low Funding

($millions)

		Heritage Reports		
	Budget	**1995 Report**	**1996 Report**	**1999 Report**
Begin Fielding	FY06	FY00		FY03
Prior year funding	799	343 (1)	343 (1)	343 (1)
1995		250	114 (1)	114 (1)
1996		300	250	265 (1)
1997		500	300	249 (1)
1998	214	950	500	217 (1)
1999	192	1050	950	450
2000	222		1050	750
2001	261		1050	
2002	291			
2003	656			
2004	872			
2005	820			
Total	**4,327**	**3,393**	**3,757**	**2,388**
Cost To Complete	8,324			

(1) Represents actual funding reported by The Heritage Foundation
Source: Various[130]

While compliance with the ABM Treaty is a significant issue, it cannot be determined to what extent this issue has limited the funding of these two programs. Both of these systems have the potential of violating several areas of the ABM treaty, specifically the Article V prohibition against sea-based NMD and the Article VI prohibition against giving ABM capabilities to non-ABM systems. However, as currently programmed, the NTW system is treaty compliant, including the unratified 1997 ABM treaty documents, unless it would be integrated with the SBIRS-Low system as discussed under Heritage Foundation recommendation 1995-3. Likewise, if even the proposed land-based NMD system is fielded, SBIRS-Low will be a component of a treaty non-compliant system that violates Article I prohibiting territorial defense.

• 1995-5. Heritage Foundation Recommendation: "*Revive space-based defense programs and direct them toward deployment*."

A space-based system is not a key component of either the proposed land- or sea-based system and would benefit both land-based and sea-based systems equally; therefore a thorough discussion of space-based defense is beyond the scope of this paper. However, space-based defenses, either kinetic kill or laser, provide for an effective first layer of defense. They are particularly effective because of the possibility of a boost phase intercept prior to the deployment of warheads and decoys. If a multi-layer system capable of blunting a major Russian attack were envisioned, this would be a key component. Space-based weapons are, however, technically difficult to develop, extremely expensive, and their survivability against anti-satellite weapons or space mines is questionable. In sum, this level of expense and effort is not required to defend against the threat as defined in this paper.

• 1995-6. Heritage Foundation Recommendation: "*Refrain from limiting missile defense capabilities in negotiating with the Russians*."

This is a political/ABM treaty issue not affecting the assessments made in this paper.

• 1995-7. Heritage Foundation Recommendation: "*Not give Russia a veto over U.S. missile defense options*."

This is a political/ABM treaty issue not affecting the assessments made in this paper.

• 1995-8. Heritage Foundation Recommendation: "*Pass a new missile defense act*."

National Missile Defense acts were passed in 1997 and 1999. While providing political fodder for pro BMD organizations due to interpretations of the act and the

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[130] Actual data derived from Budget Item Justification Sheet. All Heritage Foundation data derived from respective reports. The difference between the actual and the Heritage Foundation pre 1998 funding was noted but the author was unable to resolve this discrepancy.

inevitable ties to funding, the act may not in fact produce the consequences intended. The latest act states:

> It is the policy of the United States to deploy as soon as technologically feasible an effective national missile defense system capable of defending the territory of the United States against limited ballistic missile attack (whether accidental, unauthorized, or deliberate) with funding subject to the annual authorization of appropriations and the annual appropriation of funds for national missile defense.[131]

Recommendations of The Heritage Foundation 1996

The Heritage Foundation's second report, *Defending America: Ending America's Vulnerability to Ballistic Missiles,* is essentially a republished version of their first publication with a new introduction, conclusions and appendices. Therefore this section addresses only a few new points brought out in this 1996 publication.

• 1996-1. Heritage Foundation Recommendation: "*Congress should forgo development of ground-based systems for national missile defense and accelerate deployment of sea-based, wide area defenses. …this system could counter threats against the U.S. homeland as well as regional threats from theater missiles, beginning by the year 2000*."

A detailed comparison of the capabilities of the land- and sea-based systems will take place in the following chapter. There is, however, no evidence that a sea-based system capable of defending "the U.S. Homeland" could have been deployed by this timeframe. As of 1997 the NAW and NTW programs were on the schedule contained in Table 18. Even the further developed and significantly less challenging NAW system was not scheduled to have a contingency User Operational Evaluation System (UOES), now know as Linebacker, consisting of 35 missiles on two cruisers until FY00 with a first

[131] The House passed H.R. 4 by a vote of 317-105 on March 18, 1999. The Senate passed its version (S.257) by a vote of 97-3 on March 17, 1999. On May 20, the House approved the Senate-passed version by a vote of 345-71. President Clinton signed the bill (P.L. 106-38) into law on July 22, 1999. "National Missile Defense Act H.R.4," *Legislative Digest*, *URL <http://hillsource.house.gov/LegislativeDigest/ConferenceSummary/CSMain/cs106-3-MissileDefense.htm> accessed 16 April 2000.*

Unit Equipped in FY01. Most of the programmatic goals for the NTW system were still ambiguous with only the Aegis LEAP Intercept (ALI) testing planned for FY97-00.

Table 18: 1997 Status of Navy TBM Programs

Year	NAW Status	NTW Status
FY97	Milestone II	ALI program through FY00 10 Test Events
FY98		Milestone I Scheduled
FY99	DT/OA 8 Test Events	
FY00	UOES	
FY01	DT/OT 25 Test Events, FUE, Milestone III	
TBD		Testing against threat representative tgts. Milestone II, Milestone III, DT/OT, FUE

Source: Various

Tables 11 and 13 in the sea-based system description contain the current schedules. It should be noted the NAW system has slipped approximately two years while the ALI testing has slipped a year, and the NTW program will not currently have a FUE until FY10 although a contingency capability will be available almost 4 years earlier. This represents a recent nearly three-year slip in the fielding plan and BMDO has acknowledged this is a funding issue. However, the NTW system is fully funded through FY02 and the completion of the ALI testing and, based on the success of those tests and increased funding, the NTW program could be significantly accelerated.[132]

• <u>1996-2</u>. Heritage Foundation Recommendation: "*Congress should ensure the Ballistic Missile Defense Office develops an integrated but open architecture for battle management, command, control, and communications*."

This is a valid recommendation and would benefit any later upgrades to the BM/C3 system including integrating sea-based assets. The migration to commercial off-the shelf (COTS) open architecture systems is in keeping with current DoD directives and it is currently envisioned that the AWS will migrate to COTS equipment in the FY-07-08

[132] U.S. Congress, Senate, Senate Armed Services Committee, Strategic Forces Subcommittee, *Statement of LtGen Ronald T. Kadish*, 28 February 2000, URL

timeframe.[133] The BM/C3 architecture was well into development at the time this report was released with the first two increments being released in March of 1997. Unfortunately, while it is not a completely open architecture system, it appears "the BM/C3 system is based on existing codes, and much of it is commercially accessible," and that a "commercial approach that makes the software easy to modify" is being employed.[134]

The Heritage Foundation 1999

As this is The Heritage Foundation's most recent report it will receive the most comprehensive review. While the format and content of the report is very similar to the previous two, it does present significant new content and issues to be dealt with.

Initial Assessments

• 1999-1. Heritage Foundation Statement: "*An affordable and effective missile defense system could become operational within four years and cost less than $8 Billion*."

This statement is the foundation for the entire report and will be dealt with in much greater detail throughout the following section. However, the final analysis will conclude that this is an unrealistic timeframe and the cost analysis is questionable.

• 1999-2. Heritage Foundation Statement: "*Forward based interceptors can destroy enemy missiles early in their trajectory and thus provide the largest area of protection*."

Throughout The Heritage Foundation's publications, the ability to complete ascent phase intercepts has been specified as a key advantage of sea-based defenses. On the surface this statement is fundamentally correct; forward-based interceptors could destroy

<www.acq.osd.mil/bmdo/bmdolink/html/kadish28feb00.html> accessed on 1 March 2000.

133 Grant III, interview.

134 John Larson, TRW's Manager for the NMD BM/C3 engineering and integration effort, quoted from Kandebow, 51.

missiles early in their trajectory, and against theater range missiles the planned NTW system will possess this capability. But the benefit of being able to conduct an ascent phase intercept does not come without costs. These costs include the requirement for a very fast interceptor, an extremely robust and responsive sensor and C2 system, and a relatively accurate knowledge of the launch location. It also has the disadvantages of limiting opportunities for a second engagement, at least with the same ship, and places ships on restricted stations in harms way.

Understanding of this is crucial because without the ability to complete an ascent phase intercept, one of the most significant capability advantages of the sea-based system is eliminated. Even without an ascent phase capability the proposed sea-based NMD system would provide a very significant defended footprint by performing late midcourse intercepts; however this would require stationing Aegis cruisers near the U.S. coastline.

As can be seen in Table 19, which provides examples of the velocities required to perform an ascent phase intercept of missiles launched from various regions towards different parts of the United States, even the SM-3 Block II missiles with a V(bo) of 4.5 km/sec would be relatively ineffective for ascent phase intercepts. A V(bo) of 6.5 km/sec is really needed to provide a significant capability. It should also be noted that ascent phase intercepts are not possible against missiles launched from within China or Russia.

Table 19: Ascent Phase V(bo) Requirements

Defended Region	**NK ICBM**	**Libya ICBM**	**MRBM from Ship**	**China, Russia**
East Coast	X	Min En - 4.5 Loft - 6.5	Dep – 3.5 Others Less	Not Possible
Center of CONUS	X	Min En - 5.0 Loft - 5.5	X	Not Possible
West Coast	Min En - 5.5 Loft - 7.5	X	Dep - 3.5 Others Less	Not Possible

Hawaii	Min En - 5.5 Loft - 6.5	X	Dep - 3.5 Others Less	Not Possible
Alaska	Min En - 5.5 Loft - 6.5	Min En - 7.0 Loft - 7.0	Dep - 3.5 Others Less	Not Possible

Source: Lincoln Labs

There are basically two ways of increasing the speed of the missile: reducing the payload or increasing the size of the missile. Since significant weight savings are not likely to be realized from a 23 kg LEAP interceptor, this leaves only a larger missile. There is significant room for increasing the capability of the Standard missile and larger boosters for the Standard missile have been tested.[135] The MK-41 VLS system is also capable of handling a larger missile than the current SM-3 and the possibility of modifying the MK-41 VLS to put six missiles in a conventional eight-missile cell which would allow up to 27 inch diameter missiles has also been discussed. This would require more expensive modifications to the ships, reduces the overall number of missiles carried and no longer makes all VLS cells interchangeable. Also, as more new components are introduced, such as a new kill vehicle, a new booster, and a highly modified launcher, the system requires more development, testing and procurement time and funding. This rapidly erodes one of The Heritage Foundation's "bumper sticker" benefits of a sea-based system, which is the leverage gained from the $50 billion dollars already spent on the AWS.[136]

The second issue with ascent phase intercepts is the capability of the sensors, command and control system, and ship to react to the launch. Unlike with a late

[135] Morton Thikol has tested a 21-inch booster that would provide velocity of 4.5 km/sec. Also currently only the booster for the SM-3 is 21-inch in diameter. The remainder of the missile is only 13 inches so there is room for significant performance increase with a missile, which will fit in the current Mk 41 VLS. Grant III, interview.

[136] This statement is fundamental to the Heritage Foundation's argument and is found repeatedly in all three of the *Defending America* publications.

midcourse intercept in which the time from target acquisition to launch of the interceptor may be 20 minutes, the closer the interceptor platform is to the launch site, the less time is available to conduct the intercept. In some cases the ascent phase interceptor may have to be launched within seconds or at most minutes of the target launch. In this short period of time the launch must be detected, a track established, rules of engagement satisfied, weapon assignment made and interceptor launched. If there is even a marginal delay the interceptor will end up in an impossible tail-chase of the ballistic missile, which is now accelerating away from the defending platform. Since the most likely launch indication will be from space based sensors, although if the ship were close enough to the launch site it is possible that the threat missile would be in range of organic sensors, a reliable satellite communication link must exist at all times. This rapid response timeline would further task the BM/C3 system which as previously discussed is widely considered the most difficult component of a NMD system.

This leads to the last three issues of location, reengagement opportunities and force protection. Selecting the location requires significant compromises. Being closer to the ballistic missile launch point does provide greater defended area. However, it also requires very accurate knowledge of the launch site, it minimizes the number of launch sites which can be simultaneously defended against, it limits reengagement opportunities and it puts the ship in the most vulnerable position to an enemy attack. As the ship draws away from the ballistic missile launch point, defended area decreases but, assuming it is still stationed between the launch point and the target, all of these other factors improve. Considering that a single cruiser in Seattle with a 4.5 km/s missile and appropriate external cueing still has a large enough defended area to protect the entire lower 48 states

from a North Korean missile attack, there is little advantage to forward deploying the ship from a NMD perspective.[137] The only exception to this is if the ship were deployed far enough forward that it could destroy the enemy missile in the boost or post-boost phase prior to deploying MIRVs decoys or sub-munitions, which is highly unlikely.

Findings

• 1999-3. Heritage Foundation finding: "*The most expeditious, least expensive way to provide an effective defense against ballistic missile attack is to deploy sea-based defenses first, followed by space based defenses.*"

The current timeline for the NTW shown previously in Table 13 does not support The Heritage Foundation's claims as to the speed with which a sea-based NMD system could be deployed. While it has been acknowledged that this schedule could be accelerated, the completion of the ALI testing which would provide the engineering and testing rationale for a decision to accelerate the program is still two years away--if this testing remains on schedule. Even under ideal circumstances this makes deployment of even the basic NTW system more rapidly than the proposed land-based system unlikely, and deployment of a sea-based NMD system with all of the other external requirements impossible. These external requirements include fielding of SBIRS-Low, and modification of the BM/C3 system to include sea-based assets along with the appropriate communications links and AWS software upgrades required to integrate the AWS into the BM/C3 system.

The lack of complete cost data in The Heritage Foundation reports continues to make analysis of their claims difficult to fully analyze. As has been previously noted their estimates for the cost of fielding NTW are substantially low. Additionally, there is

[137] MIT, Lincoln Labs, *BMD Briefing*.

significant difference of opinion between BMDO and The Heritage Foundation over which costs should be attributed to the proposed sea-based NMD system. The Heritage Foundation claims these costs would be $8 billion dollars including $5 billion for SBIRS-Low while BMDO estimated the cost of a sea-based NMD system at $16-19 billion.[138] Specifically, issues in the two cost estimates include:[139]

- $2.5 to 5 billion to build 3-6 new Aegis cruisers
- $2 to 4 billion to operate the 3-6 new ships
- $8 billion for stand-alone warning and fire control sensors and battle management
- $0.7 billion for a new missile (Block II Standard Missile)

As High Frontier points out, when these costs are subtracted from the $16-19 billion cost estimate, the resulting $1.3-2.8 billion approximates The Heritage Foundation claim that the sea-based NMD system can be deployed for $3 billion more than is currently being spent. While neither the BMDO report nor the High Frontier rebuttal provide sufficient detail to adjudicate these conflicting cost estimates, some relevant issues can and must be addressed.

BMDO claims additional ships are required while The Heritage Foundation claims current ships can be modified for the mission. Each of these claims has merit. For a sea-based NMD system the existing Aegis cruisers certainly could be modified to perform the NMD mission. However, the Navy force structure is currently dropping to 116 surface combatants, while an internal study has put the number required at 138.[140] The addition of yet another mission, sea-based NMD, would unquestionably tax this already

[138] Heritage Foundation, *A Plan to Meet the Urgent Missile Threat*, 1; DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense, 20.*
[139] High Frontier, *Deception on Navy Theater Wide Costs*, Strategic Issues Policy Brief, 28 February 2000.
[140] Robert Holzer, "U.S. Navy Hopes to Expand Fleet," *Defense News*, 31 January 2000, 31.

constrained force, and the requirement for additional ships to handle this additional mission is not unreasonable. Since The Heritage Foundation plan calls for the use of very expensive multi-mission ships to perform the sea-based NMD mission it makes cost accounting difficult. Nonetheless, whether the cost is assessed as the full cost of 3-5 ships or the partial cost of 22-27 ships that perform the mission part time, there is unquestionably a significant additional sum required to provide sea-based NMD.

Next is the issue of the $8 billion dollars for stand-alone warning, fire control and battle management. The High Frontier rebuttal writes off this cost because, "The NTW system would use the sensor and battle management systems already funded elsewhere in the President's budget."[141] The reason those systems are funded is the proposed land-based NMD system.[142] If the land-based NMD system is canceled so too are those systems. Should a sea-based NMD system be chosen instead of a land-based system it is logical that those costs, which The Heritage Foundation does not deny, should in fact be assessed to the sea-based NMD system.

Finally the $0.7 billion assessed for a new Block II missile is not at all unreasonable. Upgrading from the SM-2 Block IVA Standard Missile to the SM-3 Block I, which is essentially the same missile with a third stage and LEAP replacing the warhead, and purchasing 650 of these new missiles is costing in excess of $6 billion. Further upgrades to the SM-3 missile to get to the Block II or Upgraded Block II configuration are not

[141] High Frontier, *Deception on Navy Theater Wide Costs*.
[142] A significant portion of this funding is for the SBIR program, which falls under the Air Force vice under BMDO. While a portion of this program, SBIRS-High, is necessary as a replacement for the DSP program and would need to be fielded whether or not a NMD system is fielded, SBIRS-Low and the SBIRS Ground segment are primarily required as part of the NMD system. Additionally, Baker Spring of The Heritage Foundation advocated transferring the SBIRS program to either BMDO or the Navy due to schedule slips and a failure of Air Force to give this program sufficient priority. Spring, interview.

insignificant and include a new booster and improvements to the LEAP's seeker, divert capability, and nuclear hardening.

As previously discussed, the space-based portion of The Heritage Foundation's proposal would benefit either land- or sea-based NMD and is not relevant for purposes of this paper.

• <u>1999-4</u>. Heritage Foundation finding: "*No effective defense of the entire United States can be built consistent with the ABM treaty.*"

This statement is correct. Article I of the ABM treaty prohibits territorial defense. Additionally, the treaty requires that the single authorized ABM site must be less than 150 km in diameter and include an ICBM field. This makes the mostly likely ABM treaty-compliant location the old Safeguard ABM system site at Grand Forks, North Dakota, which could leave parts of Hawaii and Alaska unprotected. Although no decision has been made as to whether the system will be fielded at all let alone its final location, all indications point towards a site in Alaska being chosen in spite of the fact that Alaska is not an ABM compliant location. However, if the NMD decision is being based on the requirements of the ABM treaty, a sea-based system is equally prohibited by the treaty restrictions on territorial defenses as well as the restrictions against mobile defenses and sea-based defenses. It is for the very reason that the ABM treaty prohibits any NMD system that this paper is not considering ABM restrictions as affecting the design, development or deployment of either system.

• <u>1999-5</u>. Heritage Foundation finding: "*The constraints preventing effective defenses are self-imposed because the ABM treaty no longer is in force as a matter of constitutional and international law.*"

This finding is also arguably true, and our strict interpretation and adherence with the treaty to date has almost certainly limited our development of NMD, both land- and sea-

based. These limitations would have been more detrimental to the development of sea-based technologies as the treaty limitations are more restrictive in this area. Even so there have been sufficient technological, fiscal and other political considerations to make it difficult to gauge to what extent ABM treaty compliance has been a limiting factor in either case. However, since the purpose of this paper is to compare these systems from this point forward under the assumption that the ABM treaty is no longer a limiting factor, this claim by The Heritage Foundation is not at issue.

• 1999-6. Heritage Foundation finding: "*Restricting national missile defenses for the American Homeland to ground-based sites requires the most expensive programs that would take too many years to complete.*"

There is no question that the NMD program will be expensive and it will take years to deploy. However, determining how the cost and timeline of the land-based system compares with the sea-based proposal is the real issue and the fundamental purpose of this paper. A great deal has already been addressed concerning The Heritage Foundation's cost and fielding claims for the proposed sea-based system, and further analysis of the two systems will be found in Chapter 6.

• 1999-7. Heritage Foundation finding: "*Defending the entire United States with ground based defenses would require multiple sites*."

This statement is incorrect and also largely irrelevant. As Table 9 shows for the C-1 and C-2 defensive capability level, the United States could be defended from a single site in Alaska. To provide the C3 capability would require interceptors at both the AK and ND sites. The sea-based system would also require numerous sites and far more missiles than the land-based system. Also, without ABM treaty restrictions there is no restriction on multiple sites. This issue will also receive further discussion in Chapter 6.

Recommendations

• <u>1999-8</u>. Heritage Foundation recommendation: "*Stop constraining the Navy Theater Wide missile defense system… in three to four years the Navy could deploy 650 fast, capable interceptors on 22 Aegis cruisers already patrolling the oceans and seas, covering almost 70 percent of the earth's surface. By linking, or 'internetting,' space-based and other sensors with its command-and-control system, the Navy Theater Wide (NTW) defense system could provide an effective global defense against long-range ballistic missiles.*"

Much of the discussion of this recommendation has already taken place. However there are three issues relevant to this recommendation which have yet to be addressed. These interrelated issues include sensor netting, missile allocation and Concept of Employment (COE) for the sea-based NMD system.

The "internetting or linking of sensors" is not specifically a NMD issue or even a NTW issue for that matter. However, the ability to link sensors offers tremendous advantages to the NTW system and The Heritage Foundation is absolutely correct that this would be a vital part of any sea-based NMD system. By linking multiple sensors it is possible to extend a ship's surveillance capabilities for thousands of miles. The most current data link presently fielded is Tactical Digital Information Link-J (TADIL-J) also known as Link-16. With TADIL-J, Aegis cruisers can share real time radar track data and information from other sources such as AWACS, Rivet Joint and JSTARS aircraft, Patriot missile batteries, units within the Marine Aviation Command and Control System; other TADIL-J equipped Navy ships and, once fielded, THAAD. TADIL-J has the capability and appropriate message sets to pass TBM data from one platform to another. However it does not allow an Aegis cruiser the critical capability of launching a missile based only on the data from the remote sensor.

That capability will be available shortly, however. Scheduled for operational evaluation in FY01, the Navy's Cooperative Engagement Capability (CEC) will provide

the capability for one Aegis cruiser to launch missiles off of data from another CEC equipped platform. Although not presently being developed it should be possible to incorporate a CEC type capability within other sensors and weapons systems such as the Marine Corps' TPS-59, the Army's Patriot AAW/ABM missile system and, when fielded, THAAD ABM system. If THAAD can be given CEC type functionality it is also logical that the NMD XBR, which is essentially a much larger version of the same radar, could also become part of a CEC type network.

For the purposes of NMD, though, what is required in addition to the links with other ground-based sensors is a link with space-based sensors. Development in this area does seem very limited. However, this integration is one of the five initiatives under the Radiant Gold program. Specifically the goal of the Aegis Cueing Initiative is "Modification of JTAGS processing software to support experiments using Aegis system at Wallops Island, in preparation for sea-borne test. Continue to examine methods to deliver cueing data to Aegis via a JTAGS remote and continue phased array antenna research for direct Defense Support Program (DSP) link."[143] Fielding of this capability would likely be considered in violation of the ABM treaty.

The integrating of sensors from multiple platforms in order to establish a sea-based missile defense network leads to the issue of COE. Typically one or two Aegis cruisers deploy with a carrier battlegroup and three or four carrier battlegroups may be at sea at

[143] Department of Defense, National Security Space Roadmap Team, "Radiant Gold," URL <www.fas.org/spp/military/program/nssrm/initiatives/rgold.htm> accessed 14 December 1999. The Joint Theater Air Ground System (JTAGS) has been operational since 1997 and is the current system which provides a direct link from the DSP satellites directly to the theater commander providing real time cueing of TBM launches. The JTAGS system consists of three eight-foot antennas to receive satellite downlink information, one 8X8X20 processing and communications van, one 60kw generator and a HMMWV.

any given time.[144] This puts possibly eight Aegis cruisers at sea at any given time which, if the sea-based NMD system is developed and deployed, might be capable of contributing to sea-based NMD. While capable of independent action the primary function of these cruisers is to provide AAW and ASW defense of the carrier battlegroup. It must be asked, can these ships continue to perform this primary mission as well as their current additional mission as a Tomahawk missile shooter, and their upcoming mission as TMD platforms and now another mission as a sea-based NMD system? Each one of these missions may require the ships to be in different locations particularly if they are netting sensors for sea-based NMD, which could require the ships to be a thousand miles apart in order to establish the best detection, tracking and shooting geometry.[145] This leads to the next question, which mission has highest priority and who controls these vessels? Who makes the decision to move an Aegis cruiser off its NMD station, leaving the United States vulnerable to missile attack? This could be one of the most important issues in regards to sea-based NMD and has never been addressed by The Heritage Foundation.

In addition to the COE questions regarding primary mission, stationing and authority over the ships, there is another question as to the required weapons load. It is not nearly as simple as allocating the 650 missiles among the 22 available cruisers. Since only one

[144] The status of the United States Navy and the carrier battlegroups can be found at www.chinfo.navy.mil/navpalib/news/.www/status.html. While three or four battlegroups may be at sea this does not mean they are in a location suited to NMD or that their assigned mission or training would allow them to be integrated into a NMD system. The makeup of a typical carrier battlegroup can be found at www.chinfo.navy.mil/navpalib/allhands/ah0197/cvbg.html.

[145] BMDO has estimated it would require three to thirteen stations for Aegis Cruisers to provide NMD of all 50 states. The unclassified version of their report does not specify what these locations are. DOD, BMDO, *Report to Congress on the Utility of Sea-based Assets to National Missile Defense*. Based on data from the MIT, Lincoln Labs, *BMD Briefing*, it appears that with stationing close to the United States, three locations would be sufficient, and as the ships were deployed further from the United States it would require more ships to cover all of the possible threat axis.

or maybe two ships would be in position to defend against any given attack, every ship performing sea-based NMD would be required to be loaded with a sufficient number of missiles to defeat the entire attack. For the proposed land-based NMD system the required number of interceptors was originally set at 20 but that number has now increased to 100.[146] An Aegis cruiser has 126 available launch cells. Therefore it could carry 20 SM-3 missiles while still having sufficient missile capacity to perform her other missions. As the number of SM-3 missiles on each ship gets closer to 100, the ship begins to become a dedicated BMD platform. If the size of the SM-3 grows to the point that six-cell launchers replace the current eight-cell launchers, this becomes even more problematic. And as the number of SM-3 missiles carried increases, utilizing mutli-mission ships becomes less and less cost effective.

While all of these issues may have viable solutions, they have not been addressed to this point. If a sea-based NMD system is going to be fielded these three issues must be resolved.

• 1999-9. Heritage Foundation recommendation: "*Expedite the sea-based system and space-based sensor systems with streamlined management modeled after the successful Polaris program. NTW system should cost less than $3 billion and could begin operation as early as 2003. The space-based sensor system should cost less than $5 billion and could begin operations as early as 2003.*"

The cost and timeline for fielding these systems has already been addressed several times and generally indicate that the sea-based NMD system could not be fielded in accordance with The Heritage Foundation's timeline. Heritage continues to justify its highly accelerated operational dates with the claim, "Years could be cut from the normal

[146] It may be required for a ship to carry as many as four interceptors for each ballistic missile it will engage. The current plan for the land-based NMD system is shoot two missiles, look and if required shoot two more missiles. Firing doctrine will be largely determined by the number of weapons required to achieve the desired P(k) against the target. A more extensive discussion of P(k) is contained in Chapter 6.

acquisition schedule by assigning a top national priority to the project and streamlining the Department of Defense's bureaucracy to implement it."[147]

The program commonly referenced in conjunction with this statement is the Polaris program. While the accomplishments of the Polaris Program were impressive, it occurred at a point in U.S. history when the Soviet threat was paramount, defense spending was much higher and the mindset of the American people was different. This success enjoyed by the Polaris program could not necessarily be repeated even with no artificial constraints and unlimited funding. In the history of the Polaris program prepared for a former Assistant Secretary of the Navy, this point is made very clear and the text specifically states:

> A program's rank on official priorities is frequently used to explain its success or failure. Programs that rank high are said to be guaranteed the resources needed for their completion; those that rank low are guaranteed starvation. Once a program has been placed at the top of a priority list, many assume that its success is assured. This explanation for success, however, neglects the question of feasibility.[148]

It should also be noted that the average time to develop and field a major system is 9.9 years and programs taking 18 or 19 years to reach Initial Operational Capability (IOC) is not unheard of.[149] Table 20 provides a listing of the time required to develop and field some other major systems.

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[147] Heritage Foundation, *A Near and Long Tterm Plan to Deploy Missile Defenses*, 51.

[148] Harvey M. Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic Success in Government*, Harvard University Press, Cambridge, MA 1972, 14. This book was recommended by Baker Spring, a national security policy expert at the Heritage Foundation, when asked to explain the references to the Polaris Program as a model for the NTW program.

[149] U.S. General Accounting Office, *Report to Congressional Requesters: National Missile Defense Schedule and Technical Risks Represent Significant Development Challenges* (Washington, DC: GAO, 1997), GAO/NSIAD-98-28, 11.

Table 20: Time Required to Develop and Field Major Systems

System	Begin Development	IOC	Elapsed Time
Longbow Apache-Airframe Modification	Aug 1985	Oct 1988	13
Comanche Program	Jun 1988	Jul 2006	18
F-22	Oct 1986	Nov 2004	18
High Speed Nuclear Attack Submarine	Dec 1983	May 1997	13
Trident II Missile	Oct 1977	Mar 1990	12
Minuteman III Guidance Replacement	Aug 1993	Jan 2000	6
Minuteman III Propulsion Replacement	Jun 1994	Jan 2002	8
F/A-18E/F Naval Strike Fighter (Hornet)	May 1992	Sept 2000	8
Joint Services Advanced Vertical Lift Aircraft	Dec 1982	Jul 2001	19
Advanced Field Artillery Data System	May 1984	Jan 1997	13
Crusader Filed Artillery System	Nov 1994	Jun 2006	12
Airborne Laser	Nov 1996	Sept 2006	10
Milstar Satellite	Jun 1983	Jun 1997	14

Source: GAO[150]

• 1999-10. Heritage Foundation recommendation: "*Revive serious research and development activities for near term boost-phase interceptors.*"

In this recommendation The Heritage Foundation is advocating "high acceleration interceptors launched at missiles in the first moments of trajectory from unmanned aerial vehicles. Later options would include space-based interceptors and lasers."[151] The use of space-based assets has already been addressed and the viability of UAV based interceptors is an entirely new area beyond the scope of this paper. The technical merits notwithstanding, if either of these systems were viable and deployed, it would be equally beneficial to a land-based system or sea-based system and does not materially affect the comparison.[152]

• 1999-11. Heritage Foundation recommendation: "End the self imposed restraints of the now defunct ABM treaty."

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[150] This report was released in December 1997 and a number of the programs listed have since slipped signiifcantly in their IOC making the developmental time even longer.
[151] Heritage Foundation, *A Plan to Meet the Urgent Missile Threat*, 3.
[152] While beyond the scope of this paper, *The Strategic Defense Initiative: A Primer and Critique*, provides detailed analysis of the cost and capability of deploying both kinetic and laser type space based-defenses capable of boost phase defense. Both kinetic and laser systems would fail the Nitze Criteria in that building additional offensive capability would be far less expensive than building defensive capability.

Again, we are currently abiding by a strict interpretation of the treaty under which no NMD is possible. In order to proceed with either NMD system the ABM treaty will have to be either renegotiated or abandoned.

• 1999-12. Heritage Foundation recommendation: "*Engage U.S. allies in building effective global missile defenses.*"

The political and international relations aspects are not being addressed in this paper. However the initial reaction from key U.S. European allies has not been favorable as, for example, permission has not been obtained to upgrade as part of the proposed land-based NMD system either of the early warning radars located in Greenland or the U.K.

Chapter 6

Analysis of NMD Options

> *The threat is so varied, and the mission demands so complex, that we do not currently have the technology to allow us to develop a single weapon system that can meet all of the demanding and complex requirements.*

Lt. Gen. Lester Lyle, Director BMDO, 14 Apr 99 Testimony

Chapter four provided a detailed summary of the current situation and the projected developmental and deployment timelines for all elements of both the proposed land-based NMD system and those elements of the AWS that The Heritage Foundation advocates accelerating, expanding and fielding as a sea-based NMD system. Chapter 5 presented The Heritage Foundation's proposal and assessed the viability of their claims. Based on that data, this chapter will attempt to make a comparison of the two proposed systems as mutually exclusive contenders for the NMD system. When assessing the proposed sea-based system, those elements of the proposed land-based NMD system that will be required for it to function will be fully attributed to the sea-based system.

It would be nice if one could simply compare the two systems according to a set of objective standards such as radar range, interceptor speed, P(k), cost, etc. But, while all of these specific bits of data are important, a close evaluation of the material reveals that many of the elements are unknown, extremely hard to quantify, or too inter-related for a simple comparison of system parameters and specifications. In some cases there was also conflicting data or opinion concerning the two systems which was impossible to

definitively resolve. In those cases, assumptions or value judgments have had to be made. Therefore, the analysis section will be presented in two parts. First will be those issues for which an objective analysis can be conducted. The second and lengthier section will provide a subjective analysis of those issues that could not reasonably be quantified.

Objective Analysis

Sensor Performance: Sea Comes Up Short

There are several sensors required for NMD other than those actually on the kill vehicle. Those sensors include the SBIRS, UEWR and fire control radars, XBR for the land-based system and SPY-1 for the sea-based system. SBIRS would be required to a greater or lesser extent for both systems, the UEWR is of primary benefit to the land-based system and the respective fire control radars are key components to each system. The following discussion will analyze the capabilities and contributions each of these sensors provides and discuss the extent to which each proposed NMD system relies on that sensor.

For the SBIRS system, the SBIRS-High component would be equally important to each proposed system. SBIRS-High would provide the first indication that a missile launch had occurred and give initial cueing data for other sensors. While the initial fielding of SBIRS-High has recently slipped two years, the operational impact is negligible as the current DSP satellites adequately provide this capability. The delay does have fiscal implications however, and can be interpreted as a lack of commitment by the Air Force to the SBIRS program.[153]

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[153] Scott, 37.

Like SBIRS-High, the SBIRS-Ground Segment is important to both systems. It would ensure rapid forwarding of SBIRS-High launch warnings. It would also process the SBIRS-Low data required for the sea-based system, which would significantly increase the capabilities of the land based-system beyond the C-1 capability level. As the sea-based system would be totally reliant on this data, many of the functions of the SBIRS-Ground segment may need to be integrated directly into the AWS. This alone could be a massive undertaking and could well exceed the processing capabilities of the current system. Even if the AWS system is capable of processing the additional code, the ongoing effort to integrate the TBM software into the AWS should demonstrate the complexities and time required to complete this task. Providing connectivity to the SBIRS-Ground system would also require providing additional high-speed satellite communications capabilities to the Aegis cruisers. The Radiant Gold program is working in this area.

Discussion of the SBIRS-Low component cannot be done independent of the UEWR and without appreciating the vast inequity between the capabilities of the XBR and the SPY-1. The SPY-1 is an E/F (2-4GHz) band radar with 4100 radiating elements and 4 megawatts radiated power. In its current configuration the SPY-1 can track a notional reentry vehicle at 190km. With the upgrades included in the NAW system, this will increase to 300km, and for the NTW system it should be as far as 500km.[154] The XBR operates in the 8-10 Ghz range, has 81,000 elements and radiated power measured in gigawatts. The prototype XBR used in IFT-4 with less than 17,000 of the 81,000

[154] The detection ranges of the AN/SPY-1 radar are classified and the specified ranges are estimates of the detection range against a separating reentry vehicle. These estimated ranges may be somewhat conservative, particularly for the current capability, however the maximum range is acknowledged to be significantly less than that of the THAAD radar, which has a range of 1000km. Grant III, interview.

elements to be used in the deployed version exceeded expectations, detecting and tracking the reentry vehicle in excess of 2000km. The deployed XBR should have a range of 4-5000km. Although specific information on this issue was not available, generally both larger arrays and a higher frequency increase the range and accuracy of a radar system. Increased accuracy is particularly important in developing the target object map (TOM) and discriminating between the reentry vehicle and decoys. Table 21 illustrates the impact of radar range on the maximum distance at which a target could be intercepted for various speed targets and interceptors. The maximum intercept distance of course directly relates to the defended area.

Table 21: Max Intercept Distance (km) as a Function of Radar Range and Interceptor Velocity

Radar Range (km)						
3km/sec Interceptor						
4000	2388	1984	1689	1481	1313	1179
1000	588	485	411	356	313	279
500	288	235	197	169	147	129
300	168	135	111	94	80	69
4.5km/sec Interceptor						
4000	2755	2382	2096	1871	1689	1538
1000	678	582	508	450	403	364
500	332	270	244	213	189	168
300	194	162	138	118	102	90
6km/sec Interceptor						
4000	2985	2646	2376	2154	1970	1813
1000	735	647	576	518	480	429
500	360	300	276	245	220	198
300	210	180	156	136	120	106
	2	**3**	**4**	**5**	**6**	**7**
Target Velocity (km/sec)						

Note: Distances are slant range and a 10 second delay from target acquisition to missile launch is applied to allow for tracking, intercept computation, weapon assignment and launch.

The SBIRS-Low component is not required by the land-based NMD system at the C-1 capability level. This is due to the data provided by the UEWR system and the 4-

5000km range of the XBR, the combination of which provides the land-based system with adequate data and range to intercept rogue nation type ICBMs aimed anywhere at the United States. The SBIRS-Low does become essential for the land-based system to engage the more capable threats encountered at the C-2 level and beyond. However, once SBIRS-Low is fielded there is no longer a requirement for the UEWR system to support the land-based NMD system.

On the other hand, the sea-based NMD system has no requirement or use for the UEWR system as its data is inadequate to properly cue and launch an interceptor. However, the sea-based NMD system is completely reliant on the SBIRS-Low system if it is to be capable of intercepting ICBMs. Depending on how the sea-based NMD system is developed the SBIRS-Low data would be required at a minimum to provide cueing to the AWS so its SPY-1 radar knows where to search, allowing it to rapidly detect and track the reentry vehicle. Under a more robust design SBIRS-Low would be required to provide tracking information prior to the reentry vehicle entering the Aegis system's organic radar search volume.

It is possible to develop the capabilities of the sea-based NMD system in four ways. The least capable but easiest to develop architecture would utilize the SBIRS-Low data only for cueing purposes, which would not allow the interceptor to be launched until the target was within range of the cruiser's organic radar. As shown in Table 22 this method, utilizing only the Aegis cruiser's organic radar, limits the SM-3 missile to less than one percent of its kinematic capability.

Table 22: Engagement Volume Limitations Due to the SPY-1 Radar

(Given as percentage of kinematic capability of the SM-3 Missile)

TBMD System	Autonomous Operation with SPY-1	DSP/SBIRS-High Cueing to SPY-1	THAAD GBR Tracks to SPY-1	DSP/SBIRS-High Cueing to THAAD GBR Tracks to SPY-1	SBIRS-Low Tracks to SPY-1	SBIRS-Low Tracks to THAAD GBR Tracks to SPY-1
SM-2/SPY-1	14	35	65	91	95	95
SM-3/SPY-1	<1	1	4	27	5	35
SM-3/SPY-1+6dB	<1	6	4	27	11	35

Source: Institute for Defense Analysis, Interoperability Opportunities in Theater Missile Defense

The next level would be to develop the CEC capabilities to allow launch of the interceptor based on another Aegis cruiser or destroyer's radar data or perhaps off of data from a THAAD radar if CEC were integrated into that system. In conjunction with SBIRS cueing, this would greatly expand the capability out to 27 percent of the SM-3's capability. The interceptor in this case still could not be launched until the target was within the search volume of one of the terrestrial radar systems.

Table 22 shows that going one step further and designing the system so the interceptor can be launched based on SBIRS-Low track data while still being required to complete the intercept within the search volume of a terrestrial radar expands the envelope to 35 percent of the SM-3's kinematic capability. The final level, which is not shown on the Table but would maximize the capabilities of the system, would be an SM-3 intercept based solely on remote data received from SBIRS-Low and relying on the SPY-1 radar as only a communication link. This dramatic expansion of capability as SBIRS-Low data is better exploited highlights the importance of that capability to the sea-based NMD system.

The capability to pass ballistic missile track data was demonstrated in November 1999 in the Target Test Vehicle-1 evaluation.[155] While the ability to link multiple platforms significantly increases the capability of the sea-based system, it also substantially complicates the process and increases the assets required. To make this work requires the tightly coordinated effort of CEC capable ships and possibly radio relay aircraft continuously on station in very specific locations. It should also be noted that even using this complicated link architecture, the sea-based system is less capable than the land-based system with a single XBR. Since deployment of the SBIRS-Low system will not even begin before FY06 and it will require a number of years to deploy the entire constellation, there is no benefit to expedited fielding of a sea-based NMD system unless SBIRS-Low fielding can be expedited as well.

Additional benefits of SBIRS-Low to either system include its ability to provide target discrimination and TOM, and assisting the interceptor to select the reentry vehicle from among decoys and other objects in the sensor's field of view. While this capability is certainly beneficial for the land-based system, it is absolutely essential for the sea-based system due to the limited capabilities of both the AWS organic radar described above and the LEAP's sensors, which will be discussed in more detail later.

[155] From 18-20 November, on the Pacific Missile Range Facility, the USS Lake Erie (CG-70) and USS Port Royal (CG-73) demonstrated the capability to pass target cueing and tracking information to each other as well as other missile defense systems that were participating in the test. Also participating in this test were the USMC, Air Defense Communication Platform (ADCP) at Camp Pendleton, the U.S. Army's Patriot and THAAD systems located at Huntsville, AL and a Gulfstream-1 aircraft functioning as an Airborne relay. During this testing, which involved the launch of a Terrier Missile Target-2 (TMT-2) on 18 November and a Target Test Vehicle-1 (TTV-1), the USS Russell (DDG-59) collected data to support SPY-1 radar discrimination techniques. Department of Defense, United States Navy, N-86, "Navy Area Theater Ballistic Missile Defense and Linebacker," URL <http://surfacewarfare.nswc.navy.mil/n86/lib_navytbmd.html> accessed 9 April 2000.

Booster Performance: Land--Further, Faster, Higher

The three-stage booster for the NMD is designed specifically to meet the requirements of placing the EKV in the proper location and on a trajectory in which it can complete the intercept. As a new development program, the booster for the land-based system was constrained only by the technology base required to design this new booster. The booster for the sea-based proposal has the same objectives regarding the placement of the kill vehicle, however it is based upon a legacy system with the basic parameters already established and numerous constraints on the size and weight of the missile due to the existing launch platform.

In spite of these constraints, there are several advantages to the use of a legacy system. It is a proven missile with an extremely good track record. The infrastructure to produce the missile is established and developmental and production costs and time are less than for a new development missile. The SM-3 successfully passed its first sea-launched flight-test in September 1999 and demonstrated reliability during launch, booster separation, airframe performance, and second stage guidance and control.[156] Although it has yet to be flight-tested, the third stage motor has undergone four successful ground tests and should be flight-tested on the SM-3 booster in the second quarter of FY00. The actual booster for the GBI won't be tested until late in FY00 and it will not be tested as part of the NMD system until IFT-7 in FY03.

While the SM-3 booster has a solid track record and is further along in testing, it will not be as capable as the eventual NMD booster. In addition to lifting a payload three times as heavy, the NMD booster will provide a V(bo) of 6-8km/sec compared to

[156] "Standard Missile-3 Completes First Test Flight," *Defense Systems Daily*, 28 Sep 99, URL <http://defence-data.com/archive/page5351.htm> accessed 15 November 1999.

3.5km/sec for the SM-3 Block I and 4.5km/sec for the SM-3 Block II if that missile is developed.[157] The greater payload weight provides for a more robust kill vehicle and the higher V(bo) substantially increases the defended area as will be discussed later.

Kill Vehicle Performance: Sea--A LEAP Behind

The capabilities of the kill vehicle are arguably the most important characteristics of an ABM system because if the kill vehicle is not capable of completing the intercept, proper performance of all of the previous steps is irrelevant. This point was driven home by the results of the recent IFT-4. It appears that all of the detection, tracking and command and control components of the system performed properly as did the interceptor until the last six seconds, but the bottom line is the reentry vehicle was not intercepted. It is also the kill vehicle that requires some of the most demanding technological advances to develop. In discussing the NMD system, John Peller, the NMD program manager for Boeing, stated that, "there are three technical long poles, …The first is whether the infrared seeker will work in the space environment with the possible distractions from kill vehicle debris and thruster exhaust… The second long pole is the hit-to-kill maneuver… Finding the warhead among the other objects is the third pole."[158] All three of these hurdles are related to the kill vehicle.

In this area, the larger and more capable EKV used in the land-based system is unquestionably superior to the LEAP used in the sea-based system.[159] The EKV uses dual band IR sensors and an optical telescope giving it the ability to detect and track

[157] Initial references called for an 8km/sec NMD interceptor; however, more recent data gives the speed of the NMD interceptor as 6-7 km/sec.
[158] Michael A. Dornheim, "National Missile Defense Focused on June Review," *Aviation Week & Space Technology*, 16 August 1999, 66.
[159] The EKV is 55 in. long, 23 in. diameter and weighs 121 lbs. The LEAP must fit on a 13 in. diameter missile and weighs from 18-23kg (40-50lbs).

targets in excess of 1500km. The LEAP utilizes only a single band seeker and is designed to track at ranges up to 300km.[160] Given the numerous steps the kill vehicle must perform--target detection, target discrimination, and diverting the kill vehicle to complete the intercept--this five-fold range increase provides an immense advantage. The use of dual band sensors also provides significant additional capability in detecting the target, but even more important is its ability to discriminate between decoys and the actual warhead. In all four of the EKV flight tests decoys have been used and the EKV was able to select the proper target.[161] None of the earlier LEAP flight tests demonstrated the ability to discriminate between the reentry vehicle and decoys. The first in-flight sensor test of the LEAP as part of the NTW system will not occur until late in FY00. Since this test is for a theater type missile, which is much less likely to carry decoys, there are no indications they will be included in this test.[162]

The EKV also has a greater divert capability than the LEAP. This problem is compounded by the limitations of the organic sensors on the Aegis cruiser and shorter-range sensor onboard the LEAP. Both of these limitations increase the required divert capability of the interceptor. The limitations of the organic sensor require the interceptor to be launched utilizing data from remote sensors, which may be slightly less accurate than data from an organic sensor or present some latency issues.[163] Compounding this

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[160] Lightweight Exoatmosheric Projectile, <http://flthlpdsk. Chinalake.navy.mil/help2/weapons/leap.htm.> accessed 24 June 1999.
[161] Although they were non-intercept tests, in IFT-1A and 2 the Boeing and Raytheon EKVs were able to discriminate between the target and a field of 9-12 other objects including decoys, the booster and Mars in their field of view. During IFT-3 the EKV initially identified a decoy and kept searching for the target. Unable to locate the target it locked onto the decoy. After centering its field of view on the decoy it detected the target and transitioned from the decoy to intercepting the proper target. During IFT-4 it appears the EKV initially discriminated between the decoy and the correct target.
[162] The ability and testing of the NTW system against decoys is classified, however there will be some decoy discrimination capability included on or before the Block II system. Grant III, interview.
[163] Mr. Ben Riley, Office of Naval Research, interviewed by author 6 December 1999.

problem, the shorter-range sensor on the LEAP gives it less time to maneuver to complete the intercept requiring a greater divert capability. However, the LEAP appears to have sufficient divert capability to support engagement of unsophisticated NMD threats.[164]

A final weakness of the LEAP is that, if required to defend against several reentry vehicles in close proximity, it does not have sufficient nuclear hardening to allow it to fly through the effects of the nuclear blast created by a salvage-fused nuclear warhead intercepted by a previous kill vehicle.[165]

The increased capabilities of the EKV could be engineered into the LEAP in one of two ways. Either the components of the LEAP could be further miniaturized, which would not be a rapid solution if achievable at all. Or the size and weight of the LEAP could be increased. Increasing the size and weight is equally problematic due to the limitations of the current missile and the capabilities of the MK-41 VLS. It should also be noted that as a general rule, a 1-pound increase in payload requires a 10-pound increase in fuel, which can result in the requirement for a significantly larger missile.

Subjective Analysis

The Timeline: Land by a Nose

The timeline can be viewed as either an objective or a subjective issue. Objectively, there are established timelines for both systems which, if adhered to, will result in their eventual fielding. According to the timelines as presented earlier the proposed land-based system with an IOC of FY05 would have a significant advantage over the sea-

[164] DOD, BMDO, *Utility of Sea-based Assets to National Missile Defense*, 11.

based system which will not have even a contingency capability until FY06 and will not be fielded until FY10. Once more this schedule is only for a theater capability and there is no existing program to field the sea-based NMD capability at all. It is generally accepted, however, that at least a partial sea-based NMD capability could be developed within four years of fielding the NTW system if the program is funded and defined now. That schedule puts the lesser sea-based capability five to nine years behind the land-based program. However, the timeline rapidly becomes subjective when other factors are added to the equation. These complicating factors include programmatic risk, technical hurdles, system testing and of course funding, each of which will be discussed below.

Programmatic Risk: Both Teams Try the Hail Mary

There is unquestionably significant programmatic risk involved in both the proposed land-based system and the current NTW system. The proposed land-based system was upgraded from a Technology Readiness Program to a Deployment Readiness Program in FY96 in what was known as the 3+3 program where three years of development would lead to a deployment decision with fielding of the system within three more years of that decision. The effect of this upgrade "compresses what is normally a 6-12 year development program into three years with some additional development concurrent with a 3 year deployment."[166] This original plan was then adjusted to the current 3+5 plan with the President scheduled to make a deployment decision in the summer of FY00 as President Clinton is planning to do, and fielding within five years after that decision. Even the 3+5 plan demands a very aggressive schedule as the report of the *Welch*

[165] DOD, BMDO, *Utility of Sea-based Assets to Ntional Missile Defense*, 11.

[166] Department of Defense, Chairman Joint Chiefs of Staff, *Letter to Senator Inhofe*, 24 August 98, URL <www.clw.org/pub/clw/ef/shelton.html> accessed 23 June 1999.

Committee which was convened in the summer of 1999 to review the NMD program points out: "The panel believes there is a legacy of over-optimism about the state of progress in developing hit-to-kill performance."[167] The November 1999 report went on to cite numerous areas of risk/concern in the proposed land-based system including: a highly compressed schedule, large scale integration issues, the government's program managers not having authority commensurate with their responsibility of running the program, the EKV program being hardware poor, and entanglements with arms reduction agreements.

Regarding the NTW, though it is an incremental upgrade to an existing system and on a longer timeline, the Director of Testing and Evaluation report states, "NTW is a high risk program with several challenging technical aspects."[168] While the level of risk for the current NTW system is high, it is still significantly less than the risk involved in the proposed land-based NMD system. However, the assessment by the DOT&E was based on the current programmatics and three sets of incrementally more challenging flight tests continuing through FY07. Increasing the rate of development or increasing the overall capability to the level required for NMD would obviously substantially increase the risk factor, and doing both would almost certainly put the risk factor beyond that of the land-based system.

Testing: Land 4 - Sea 0

While testing schedules can be accelerated, previous experience with ABM systems has demonstrated the opposite trend is the norm. The NMD IFT-3 was 21 months behind

[167] *National Missile Defense Review (Welch Report)*, November 1999, URL <www.acq.osd.mil/bmdo/bmdolink/htmldocs.html> accessed 16 December 1999.
[168] DOD, DOT&E, *DOT&E FY98 Annual Report*.

schedule, THAAD experienced approximately a one year slip for every year planned in the program and the next ten NAW have slipped 18 months due to software integration problems.[169] Given this track record, and the numerous references by the Director of Testing and Evaluation in his annual reports and the comments in both reports by General Larry Welch referring to each program as accelerated and high risk, the current testing schedule will be assumed to be the most rapid practical rate of development for the land-based system. Although, depending upon the outcome of the ALI testing there may be some room for improvement in the NTW schedule, it will be assumed sea-based NMD will also remain on its current schedule.

The land-based NMD system calls for seventeen more tests to be conducted with each test utilizing fewer surrogate systems and incorporating more actual components of the proposed system. Test thirteen will be the first to use the actual EKV and all tests after that will utilize all of the actual system components. The limited flight-testing for this system (its predecessor, the Safeguard system, underwent 111 flight tests when it was fielded) is of significant concern and the Director of Operational Testing and Evaluation has cited ten specific areas that the flight-test program does not adequately address. In addition to time, the flight-testing is also limited due to cost. The estimated cost of the last test, IFT-4, is estimated to be $100 million, which makes as extensive a flight-testing program prohibitive. The lack of flight-testing is hopefully addressed by simulation which accounts for about two-thirds of the testing program.[170]

By contrast, the proposed flight-test program for the NTW system is somewhat more robust and is divided into three blocks totaling 35 flight tests, which the Director of

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[169] "Navy Area Defense System: Interceptor Builds on Aegis Success."
[170] Dornheim, 38.

Operational Test and Evaluation considers adequate for this program. It must be noted however that all of these tests will be against a single warhead launched by the single-stage ARIES or two-stage HERA target missiles with a maximum range of 1140km. These tests are much less demanding than the NMD tests against multiple objects at a range of 4300km. If the NTW system is going to be expanded to a NMD capability it would also have to face these much more demanding tests.

Although with an acknowledged level of risk, the current flight-test programs for both systems support the requirements of their respective programs. However, at the successful completion of these programs the land-based system will have demonstrated a NMD capability and the sea-based NTW system will not have demonstrated this capability. Nor is there any planned testing of the sea-based system in that area.

Cost: Land Says "Show Me the Money." Sea Demands More

> *Cost exchange analyses are essential in evaluating a proposed defensive system. If it costs the offense less to counter a defense than it costs the defense to deploy one, it is disadvantageous usually to proceed with the defense.*
>
> Paul Nitze, February 1985[171]

NMD is an extremely expensive endeavor and it is questionable whether either proposed system would pass the Nitze test. As shown previously in Table 8, BMDO Funding by Category, since 1985 well over $50 billion has been spent on BMD. Of that sum, $20 billion has been spent specifically on NMD. In all since the mid-1950's it has been estimated that $100 billion has been spent on BMD.[172]

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[171] The concept of "cost effectiveness at the margin" as explained above was enunciated by Paul Nitze, a senior specialist in arms control for the Reagan Administration, in a speech before the Philidelphia World Affairs Council in February 1985. From Jungerman, 13.

[172] This estimate was made in 1997 using 1996 dollars. Stephen I. Schwartz, "Missile Defense," *Defense News*, 3 February 1997.

The most current projection for the future cost of the land-based NMD system is approximately $13 billion for construction through FY07, and $26.6 billion for construction and 20 years of operation.[173] It must also be kept in mind, however, that these are only estimates. According to Steve Kosiak, director of budget studies at the Center for Strategic Budgetary Assessments:

> On average, the actual cost of acquiring a weapon system such as a fighter jet is 20 percent higher in real terms than the estimate drawn up when full-scale development began…Something as sophisticated and complex as a ballistic missile defense system, the odds are it's going to have even more significant cost growth. Instead of 20 percent, the cost increase for missile-defense systems could reach 40 percent.[174]

The cost to develop and deploy the NTW system including 80 missiles on four ships is currently projected at $5.5 billion.[175] This is of course not an accurate figure for comparison with the proposed land-based system because at that point the NTW system possesses no NMD capabilities and many of the components of the NMD system that would be required for a sea-based NMD system are not included. Given additional time and funding, the NTW unquestionably will gain some NMD capabilities whether it is employed in such a role or not.

Going beyond these bottom line figures in analyzing the relative cost of these two systems, the concerns are threefold. The first concern is that while the proposed land-based system has a known set of costs, the sea-based system does not. Deciding what incremental costs of the sea-based system are attributed to the NMD portion of this system were it expanded and employed in such a manner is very subjective. This

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[173] The $26.6 billion is cited in DOD, DOT&E, *DOT&E 1999 Annual Report*. VI-5. A more recent article has since cited the 20 year life cycle cost as $30.2 billion. John Diamond, "Cost for Missile Defense Soaring," *Chicago Tribune*, 5 April 2000. The $13 billion includes a $2.2 billion plus up over the FYDP. Gopal Ratnam, "NMD Could Get $2.2 Billion Windfall in 2001," *Defense News*, 21 February 2000, 26.
[174] John Donnelly, "Cost of Initial NMD to Rise 50 Percent," *Defense Week,* 20 Dec 99.
[175] DOD, DOT&E, *DOT&E 1999 Annual Report,* VI-21.

subjective cost assignment is one of the factors in The Heritage Foundation's unrealistically low cost assessments for the sea-based NMD option. Beyond assessing the NMD related procurement cost, this ambiguous assessment of costs becomes even more controversial when applied to the operational funding associated with the Aegis cruisers. As the NMD mission could consume a significant percentage of the ships' overall training and operations time, how are the manpower, training, and operations and maintenance dollars equitably attributed in order to determine a fair cost comparison? As the sea-based NMD program is currently undefined and there is no Concept of Operation on which to base this analysis, actual costs are very difficult to quantify and speculation on any actual dollar figures is very subjective at this point.

The second concern is that many components of the proposed land-based system would also be required for the sea-based system in order for it to truly have a NMD capability. This includes the BM/C3 system, which would most likely be more complicated and more expensive if sea-based assets were employed. This assessment is made due to the large number of mobile launching platforms; a minimum of 22 cruisers would need to be integrated into the system, instead of integrating one or two fixed land-based interceptor sites. One of the most costly components of either system would be the SBIRS. Both systems require the SBIRS-High and SBIRS-Ground segments at a cost of $7.6 billion dollars and the SBIRS-Low segment at a cost of over $8 billion would be required for the sea-based system at all capability levels and for the land-based system beyond the C-1 capability level.[176]

[176] As an Air Force program for the replacement of the current DSP satellites, required for ballistic missile warning whether a NMD system is deployed or not, the SBIRS-High program costs are usually not included in NMD costs estimates.

The third concern is establishing, for the given cost of the two systems, whether both would be providing the same level of defensive capability, and if not, what incremental costs would be required to bring the two systems to parity for comparison purposes. Due to fundamental differences in the two systems, which will be detailed in the capabilities analysis later in this chapter, this task alone is extremely complex.

With those difficulties in mind, several assumptions will be made that will frame the final cost assessment of the competing systems. These assumptions, however, are applicable only for the cost assessment. The first assumption is that the cost of developing, building and operating the BM/C3 system and the SBIRS is equal for either proposed NMD system. With those components eliminated the comparison is reduced to the GBI, GBR and IFICS of the land-based system versus the Aegis cruiser and the associated upgrades on the sea-based system.[177] The second assumption is that the two competing proposals of 100 interceptors at a single land-based site and 650 interceptors available to 22 upgraded Aegis cruisers will each provide a different but equal capability against the threat as depicted in chapter three. A third assumption is that, due to the specific patrol areas required for an Aegis cruiser to perform NMD, and the fact that with a load of 100 SM-3 missiles almost 85 percent of an Aegis cruiser's VLS system would be filled by missiles capable of engaging only ballistic missiles, these ships are in fact dedicated to NMD and not performing their traditional mission of CVBG defense or assignable to perform Tomahawk attack missions.[178] This last assumption is not shared

[177] During the initial deployment the land-based system will also use a network of upgraded early warning radars, however since the presence of SBIRS-Low is being assumed, this ground based radar network would no longer be required, so it would be unfair to penalize the land-based system with the associated costs of upgrading and operating this system.

[178] According to the BMDO report on sea-based missile defense it would take at least three Aegis cruisers to provide defense for the entire United States and it is assumed that each cruiser would be defending against a different threat axis, each individual ship would be required to be capable of providing the entire

by The Heritage Foundation, which bases all of their estimates on the Aegis cruisers performing the NMD function with no interference to current deployments, patrol patterns or missions.

The analysis of the cost will be broken down into four areas, development, infrastructure (ships versus land-based installations), missiles and personnel. As will be seen, given the above assumptions, the cost analysis will weigh heavily in favor of the land-based system.

The developmental costs for the GBI and GBR are currently estimated at $1,092 million and $283 million respectively.[179] It is not as simple to arrive at the developmental costs for the sea-based system; however; the cost of upgrading the NTW to a sea-based NMD system should not be underestimated. The cost through the demonstration and validation phase of modifying the SM-2 Block IV to the SM-3 Block I is currently estimated at $2.15 billion.[180] BMDO has estimated it would take another $700 million in RDT&E to upgrade to the Block II capability needed for sea-based NMD.[181] In addition to the missile upgrades there would be additional costs required to upgrade nearly every component of the AWS. For a sea-based configuration designed to augment the land-based NMD system with two Aegis cruisers the costs were estimated to be $500 million for adding sea-based NMD radars and associated software integration. And an additional $500 million to install the communications hardware and perform the

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defensive mission. Therefore, for them to have the same capability as the land-based system it will be assumed that each cruiser carries 100 interceptors.

[179] Department of Defense, Ballistic Missile Defense Organization, "BMDO RDT&E Budget Item Justification: PE 0603871C NMD DEM/VAL," February 1999.

[180] Department of Defense, United States Navy, "PE 0603868C Navy Theater Wide - DEM/VAL," February 1999, 6, URL <www.dtic.mil/comptroller/fy2000budget/index.html> accessed 12 April 2000.

[181] DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense*, 20.

software integration necessary to tie the ships into the national BM/C3 system.[182] Depending on the final configuration of the Block II interceptor there may also be costs required to modify the MK-41 VLS for improved flame handling or to develop a six cell configuration for the SM-3 Block II missiles. Although these estimates are by no means all inclusive, the developmental costs for the sea-based system appear to be approximately $500 million more than the land-based developmental costs.

The next issue is infrastructure costs. The cost of a 100-interceptor GBI complex at Fort Greely, Alaska, the most expensive of the sites under consideration, is only $626 million and at Grand Forks the GBI site would cost only $312 million. There would also be the construction costs of the XBR site, which could be as much as $71 million and the cost for one or more IFICS sites.[183] This makes construction of the infrastructure for even the most costly single interceptor site land-based system under $1 billion.

Once more the issue is not as clear-cut for the sea-based NMD option. The Heritage Foundation maintains no additional ships are required while BMDO estimates that an additional 3-6 Aegis cruisers would be required. As stated in assumptions preceding the cost estimates, the cruisers performing NMD would most likely have to be dedicated to the NMD mission, therefore the BMDO request for additional ships is logical. Further supporting this assessment are the following factors.

To keep one ship permanently on station can require five to seven ships in order to account for maintenance, training, and transit time.[184] This implies that it could require the support of at least 15 of the 22 existing Aegis cruisers just to keep three ships on

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[182] DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense*, 20.
[183] The cost estimate for the IFICS were not available, however they would almost certainly be significantly less than the larger more complicated GBR site.
[184] Holzer, "U.S. Navy Hopes to Expand Fleet," 20.

station to perform the NMD role. Due to existing shortfalls in the number of Aegis equipped vessels, shortfalls which will only increase with the addition of the TBM mission, the Navy is looking at adding five additional Arleigh Burke class destroyers at nearly $1 billion dollars apiece to the ten it already plans to buy by 2008.[185] With these factors in mind, the previous assumption and BMDO's estimate seem reasonable. Therefore, even with the minimum requirement for three new ships to support the NMD mission, the infrastructure costs for the sea-based proposal are at least triple that of the land-based system.[186]

In addition to the initial procurement costs, the operational costs must also be considered. With the assumptions made above this once more results in comparing the operating costs of the GBI, XBR and IFICS system sites with the cost of operating a minimum of three Aegis cruisers on continuous NMD patrols. The operations and maintenance cost of maintaining an Aegis cruiser at sea is approximately $2.5 million dollars per month for an annual cost of $75 million dollars, not counting any overlap in on station time, training or work-ups for ships performing the NMD mission.[187] While not a large sum in the world of BMD where most figures are given in billions of dollars, it is still significantly greater than the cost of operating their land-based counterparts.[188]

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[185] Holzer, "U.S. Navy Hopes to Expand Fleet," 20.

[186] This assumes the least expensive scenario and the purchase of three additional Arleigh Burke destroyers at $1 billion apiece. Under the most expensive scenario the sea-based option would be nine times as expensive if six Ticonderoga class cruisers were purchased for $1.5 billion apiece.

[187] The $2.5 million figure was determined by totaling the Navy's 1999 O&M costs for Mission and other Ship Operations, Ship Operational and Support Training, Intermediate Maintenance, Depot Maintenance and Ship Depot Operations Support which was $6,095,294,000 and dividing it by the 2,706 ship operating months accumulated in that same year. This is a fleet wide average including 11 aircraft carriers, 106 surface combatants, 37 Amphibious ships, 57 nuclear attack submarines, 18 ballistic missile submarines, 34 combat logistics ships, 11 mine warfare ships and 15 support ships. This does not account for funding the training and pay for a crew of 358.

[188] An accurate figure for the cost of operating the land-based facilities was not available. However DOD wide base operating costs are $12,968 billion and real property maintenance is another $5,424 billion. When these costs are totaled and divided by the DOD civilian and military manpower total of 2.106 million

One more important consideration is the personnel required to man those ships. The full compliment of an Aegis Cruiser is 346 requiring more than 1000 sailors to be at sea at any given time directly supporting the NMD mission. Overall the total number of people affected would be much higher as the possible number of ships required increased and ship rotation and additional training are accounted for. With the current recruiting difficulties and already increased operational tempo, any further increases in either of these areas must be seriously considered. By comparison it would require a total of 380-490 people to fully support a single land-based interceptor site, XBR site and IFICS site.[189]

The last cost issue is that of the missiles themselves. It may seem that 650 sea-based interceptors would provide more capability than the 100 interceptors proposed for the land-based system. However, it in fact works out almost the same for the following reason. As previously determined three ships would be at sea at any given time with 100 missiles each. Since the ships would need to be rotated on station, an additional 300 interceptors would need to be available to the ships that were relieving them, requiring at least 600 interceptors to provide the same constant coverage that the 100 land-based interceptors provide. Obviously if the Aegis cruisers were not both ideally placed and dedicated to the NMD role it could take significantly more ships and missiles to provide

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personnel, it equates to an average base operation and maintenance cost of $8730 per individual. Multiplied by the 490 personnel required for the GBI, GBR and IFICS sites gives a total operations and maintenance cost of only $4.3 million. Even if these NMD facilities cost 10 times the average they would cost only slightly more than half as much as the operational cost for the three cruisers. Department of Defense. Office of the Secretary of Defense, *Operations and Maintenance Overview: FY 2001 Budget Estimates*, March 2000. URL <http://www.dtic.mil/comptroller/fy2001budget/budget_justification/pdfs/operation/o_m_overview.pdf> accessed 16 April 2000.

[189] Department of Defense, Ballistic Missile Defense Organization, *NMD Deployment Draft Environmental Impact Statement*, September 1999 es-5, URL <www.acq.osd.mil/bmdo/bmdolink/html/drafteis.html> accessed 12 April 2000. These figures include total site related employment.

the same relative coverage. Therefore, unless significant cost advantages can be achieved elsewhere, under the best-case scenario, to be competitive with the land-based system, the sea-based interceptors would need to cost one-sixth the price.[190] It should also be noted that these same 650 interceptors are currently being designed and built for providing TBMD and it is highly unlikely that the stationing requirement would allow the same ship to perform both functions; therefore additional missiles would have to be purchased.[191]

The Heritage Foundation relies very heavily upon the argument that over $50 billion dollars has already been expended on the Aegis program therefore it could be leveraged to provide a sea-based missile defense system at less cost than the proposed land-based system. However, as has been demonstrated above, since the assets that the $50 billion dollars has purchased are already over committed, would require significant and very costly upgrades, would have higher operational costs and would require significantly more personnel, it is in fact a much more expensive option than the land-based alternative. While an exact figure has not been specified it appears that the sea-based proposal costs more than the land-based system in every category including development, construction and operations. By BMDO's estimate the cost penalty of the sea-based option is $3-5 billion or, 25-35 percent more than the current land-based proposal.[192]

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[190] The estimated cost of a single SM-3 Block I missile is $11,275,000. DOD, DOT&E, *FY99 Annual Report to Congress*. An estimated cost of a GBI was not available. However the estimated cost of each booster is $3,000,000. Therefore if the EKV costs less than $64,650,000 the sea-based system would not meet the requirement of costing one-sixth that of the GBI.
[191] DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense*, 15.
[192] DOD, BMDO, *Utility of Sea-Based Assets to National Missile Defense*, 20

Technical Hurdles: Both Teams Started with the Ball Deep in Their Own Territory

The ability to destroy a ballistic missile has come a long way since President Reagan's historic speech in March 1983. Although it is now 17 years and approximately $60 billion later and not a single dedicated ABM system has been fielded, the results of that huge investment will soon be demonstrated when over the next decade as many as half a dozen ABM systems may become operational.[193] This does not mean however that all of the obstacles have been overcome. Both the proposed land-based system and the NTW system, which would become the basis for the sea-based NMD system, still have technical hurdles to clear or demonstrate they are capable of overcoming.

Unless the testing program uncovers a major problem with the system, the majority of the technical hurdles for the land-based system appear to be solved, although some still remain unproven. This does not of course mean that there is no room for improvement or that the system is ready to be fielded, only that the majority of the individual components have been tested without any unsolvable problems. Aspects of the proposed land-based system that have yet to be demonstrated are the booster, which will not be tested as part of the system until IFT-7 in FY03, and the IFICS that should be tested during IFT-5 in FY00. In demonstrating that the system is capable of performing the required mission, there are acknowledged shortcomings in the testing program including a limited number of overall flight tests, a lack of tests against multiple reentry vehicles, and the limiting of

[193] Several systems with ABM capabilities have been fielded including later versions of the Patriot and HAWK missile systems though neither of these systems was designed as ABM weapons. The six ABM systems include the Israeli built but heavily U.S.-financed Arrow II in FY00, Patriot PAC-3 in FY01, NAW in FY03, NMD in FY05 if the deployment decision is made, THAAD in FY07 and NTW in FY07.

both range and intercept velocity due to the constraints of the Kwajalein missile test range and safety constraints.[194]

While the basic missile components for the sea-based system are well proven, it is not as well developed as the land-based system in the unique functions required to intercept a ballistic missile. The sea-based system has some technical hurdles to overcome just to get to the NTW capability and then some additional technical hurdles before it would become capable of NMD. The software integration problem is still delaying the NAW system. This of course needs to be solved prior to the fielding of NTW and will become an even larger and more complicated problem if an attempt is made to integrate NMD software into the AWS. This has the potential of being the most serious problem.

The V(bo) for the SM-3 Block I missile is only adequate for TBMD. This will be solved by the SM-3 Block II missile with the larger booster, however development of that system still needs to be completed and even the faster SM-3 Block II will have marginal performance for NMD applications and under most circumstances is inadequate for the ascent phase intercept, the most beneficial capability of a sea-based NMD system. The capabilities of the SPY-1 radar are being pushed to the limit for NTW applications and it is not likely this radar can be enhanced to make it an effective NMD sensor. While the test program is adequate for TBMD it does not begin to cover the capabilities that would be required of the system to perform NMD operations. Another phase of testing versus faster, longer-range missiles utilizing countermeasures would be required just to bring the testing program to the level of the land-based system. Finally the technical problems

[194] DOD, DOT&E, *DOT&E FY 1998 Annual Report*.

delaying the SBIRS-Low program would need to be solved and that system would have to be fielded concurrently with the sea-based NMD system in order for it to be functional.

Numerous technical hurdles have been given for each proposed system. It is impossible to state conclusively which system has the most difficult road ahead. It is safe to say, however, that the challenges that must be overcome are considerable for either system.

Capabilities Against the Threat: Choosing the Right Equipment

Going back to the threat analysis presented earlier, the ability of each system to respond to the myriad of threats will be reviewed. The primary threat justifying the deployment of the NMD systems is to defend against rogue nations possessing a few ICBMs with a range capable of striking all or part of the United States. This is unquestionably within the capabilities of the proposed land-based system and, except for Hawaii, the system would be capable of re-engaging missiles that were not destroyed on the first intercept attempt. From stations off the U.S. coast the NTW Block II system with external cueing would also be able to perform this function. However, to provide continuous defense from multiple threats it would require significantly more assets and would not have the reengagement capability of the land-based system. In a few limited applications the sea-based system may also be able to complete an ascent phase intercept. This would of course require sufficient intelligence information to ensure the ship was properly stationed, flawless integration of the BM/C3 system and a situation where the intercept geometry supported an ascent phase intercept.

The ability to defend against an accidental or unauthorized launch from Russia would probably exceed the initial capability of either system. As China modernizes her

strategic missile forces over the next decade with the mobile, solid fueled DF-31 and DF-41 missiles, these Chinese missiles too will probably exceed the initial capabilities of either of the proposed systems. At the C-3 deployment level, however, the proposed land-based system will have the capability of destroying even these sophisticated threats in limited numbers. The sea-based system could have a late midcourse capability against these more sophisticated threats; however, due to the inland launch sites, greater acceleration and higher V(bo), ascent phase intercept of these missiles is not possible by the envisioned or probably any sea-based system.

Perhaps one of the most immediate dangers, because the missile technology is already available to rogue nations and would only require developing the sea-launch platform, is the threat of a sea-launched ballistic missile attack. The more dangerous version of the sea-launch capability, the submarine, however is not likely to be a threat from other than Russia or China in the foreseeable future. In either case, if the platform is able to get within firing distance of the United States this is an extremely serious threat because due to the shorter range and reduced time of flight, the land-based NMD system would not be able to engage a sea-launched ballistic missile.[195] The proposed sea-based system would be capable of intercepting the sea-launched ballistic missiles in either the ascent or late midcourse phases; however its ability to defend against these threats would once more require proper stationing depending on the location of both the threat and target. This stationing requirement becomes even more critical with shorter-range missiles, particularly if they are fired on a depressed trajectory, due to the very small intercept window.

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[195] DOD, BMDO, *National Missile Defense Program*.

This analysis of the varied but overlapping capabilities of the two systems clearly demonstrates the benefit of deploying both systems, each one optimized for its particular strengths in providing an overall NMD architecture. As previously discussed, there would still be holes in the coverage against both sophisticated Russian systems and sea-launched systems. However with both systems in place and adequate intelligence of the existence and location of sea-launch platforms, a fairly credible defense could be developed. While the land-based segment would provide protection for the United States against ICBMs under most circumstances, the sea-based component would buttress the NMD system by providing such capabilities as a reengagement capability even for outlying locations such as Hawaii, increasing the overall number of interceptors available, allowing defense to be weighted against a particular threat axis, possibly extending BMD coverage to U.S. territories and allies, and providing critical redundancy to a system which cannot afford to fail.

Defended Area: Sea Playing Zone While Land Goes Man-to-Man

As previously stated the requirement of the NMD system is to provide protection of all 50 states against ballistic missile attack. Also previously discussed were the numerous factors that affect the ability of an interceptor to engage various types of ballistic missiles. When all of these factors are combined it is apparent that a simple statement of defended area is impossible to provide. Even given the parameters of the defensive system, including interceptor and sensor capabilities, it cannot necessarily be answered unless the specifications of the threat missile and its point of origin are also known. Given this information--for example if the threat was a 7 km/sec Taepo-Dong-2 launched from Pyongyang, an exact area could be depicted that an 8km/sec interceptor cued by

SBIRS-Low and launched from Clear Air Station, AK based upon tracking from a XBR at Shemya, AK could be determined. Likewise a defended footprint for a 4.5km/sec sea-base interceptor fired from a cruiser stationed off San Francisco using remote SBIRS-Low data versus the same threat could be specified. However, the possible number of combinations is infinite and for the purposes of this paper, this is not a practical methodology. Therefore, a subjective discussion of the pros and cons of each system as they pertain to defended area will be discussed.

Generally speaking, due to its much higher V(bo) the land-based interceptor will provide defense of a larger geographical area than the sea-based system. This greater defended footprint is further enhanced by the range and capability of its organic sensors. Offsetting this advantage for the sea-based system are its mobility and theoretical capability to perform ascent phase intercepts, a capability that would be realized if a significantly faster interceptor was employed. This faster interceptor would of course also increase the defended area for late midcourse intercepts as well. In fact a sea-based interceptor fast enough to consistently perform ascent phase intercepts would have to be virtually as fast as the proposed land-based GBI.

In lieu of this faster interceptor, the sea-based system can make up the difference in defended area by utilizing multiple platforms. While not as efficient a method for providing a continuous defense of all 50 states against strictly an ICBM threat from known locations such as North Korea or Iran, the sea-based system has the advantage that, given sufficient warning, it can be tailored to provide a more robust defense against a specific threat. Having interceptors at more locations also increases the capability to simultaneously defend against shorter-range sea-launched threats, although there is still

no guarantee that the ships will be properly stationed to defend against this threat. One other advantage of the sea-based system is that, if required, its defended footprint can be adjusted to cover areas beyond the United States. While building additional land-based interceptor sites could provide the same extended coverage, this is not a short-term capability and carries far greater political consequences than repositioning a cruiser.

Overall, as long as there are only a few known rogue nations presenting an ICBM threat, the land-based system is entirely self sufficient and a more practical alternative. However, as ICBM threats develop from more countries or a more significant sea-launched threat develops, the sea-based system, particularly with an improved interceptor, adds significant capability to the land-based system.

P(k) Considerations: Trying to Beat the Spread

The probability of kill sounds like another issue which should be in the objective section instead of the subjective--after all is it not simply a number and if the land-based system has a P(k) of 0.95 and the sea-based system has a P(k) of 0.90 the land-based system is better? Unfortunately, as with so much else relating to NMD this issue is very complicated. The requirement has been reported to be against an attack of five missiles for the NMD system to have the ability to have a 95% confidence that a 95% kill probability will be achieved. To get this level of confidence a shoot-look-shoot scheme is used. Two interceptors are fired at a warhead, the damage is observed, and another two interceptors are fired.[196] This requires that four interceptors be available for every reentry vehicle that must be intercepted. If decoys are used that cannot be discriminated

[196] Dornheim, "National Missile Defense Focused on June Review."

from the reentry vehicle, interceptors can rapidly be depleted as each decoy that cannot be discriminated must be intercepted.

While this sounds like a reasonable requirement it does not appear to account for the complexity of the system and to define the set of parameters which will affect the determination of P(k). For a system of this nature, where failure is not an option, the determination of its P(k) must start at the very beginning of the process and work systematically through each and every step of the process. A few of the major steps in this process include detection, tracking, discrimination, sensor handoff, BM/C3 functionality, and interceptor performance. And the probability of completing each one of these steps is affected by the type of missile(s) launched, the number of missiles launched, the location(s) of the missile(s) launched, the location(s) of the target(s) etc. Additionally, the enemy can attempt to lower the P(k) by either physical or electronic attack on any or all elements of the missile defense system.

It would be possible, assuming that the detection, tracking, and BM/C3 functions are all completed and the resulting intercept is calculated to fall within the kinematic capability of the interceptor, to have a known P(k) for that particular set of conditions. However, given all of the considerations provided above, establishing a meaningful, objective scientifically determined P(k) is a daunting task.[197] In the absence of even a simple P(k) for an individual intercept let alone a comprehensive P(k), taking all of the above considerations into account, the following issues are presented which may affect the P(k) of one system more than another.

Given that SBIRS-High and Low are used for initial detection and tracking, then either system would be equal in this area. Assuming the reentry vehicle would at some

point be within the kinematic capability of both systems, all P(k) factors beyond this point would have to fall in favor of the proposed land-based system. The proposed land-based system would be able to launch the interceptor utilizing its organic XBR whereas the sea-based system would be using remote data. The proposed land-based system uses a faster interceptor with a greater divert capability. The range of the EKV sensor is far greater than that of the LEAP. The EKV utilizes multi-spectrum sensors. This is by no means a comprehensive list of the steps required to complete the intercept and even if each one of these functions provided only a minute advantage to the land-based system, the cumulative affect would be significant. In addition to having a higher single shot P(k), the fact is that the longer range of the land-based system would increase the likelihood of being able to reengage reentry vehicles which were initially missed. The one possible advantage of the sea-based system is that the P(k) against a reentry vehicle that never passes within the kinematic capabilities of the interceptor is naturally zero, and the flexibility of this system under ideal circumstances may allow it to be positioned to engage reentry vehicles the land-based system could not.

Countermeasures: Land Able to Read the Offense

As with many of the issues discussed here, countermeasures could have been included under several areas including technical hurdles, testing, or NMD capabilities, as certain aspects of defeating countermeasures fall into each of these categories. In attempting to defeat an ABM system there are numerous countermeasures available including actions to reduce radar and IR signature of the actual reentry vehicle making detection and tracking more difficult, or deploying one or more decoys in close proximity

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[197] Ben Riley, interview.

to the warhead in an attempt to confuse or divert the interceptor. The effectiveness of countermeasures, particularly decoys, depends greatly on the type of intercept to be completed--boost, midcourse or terminal. Since both of the proposed systems are designed for midcourse intercepts, decoys can effectively be employed with similar effect on both.

Although the specific techniques used to select the reentry vehicle from decoys tend to be some of the most classified issues in ballistic missile defense, there are some considerations that would indicate the proposed land-based system with the EKV is more capable then the proposed sea-based system with the LEAP. Once more we must assume the SBIRS-Low is deployed in conjunction with the sea-based system making the discrimination capabilities of the initial tracking system equal. However, prior to the deployment of SBIRS-Low the UEWR will provide a Target Object Map (TOM) and some discrimination capability for the proposed land-based system. After receiving cueing and TOM data from either the UEWR or SBIRS-Low, the land-based XBR will then be able to track the target field and perform additional discrimination algorithms prior to launching the interceptor or while the interceptor is in flight prior to release of the EKV. However the sea-based NMD system would be required to launch an interceptor relying solely on SBIRS-Low data, and the system may be developed so that in many cases the Aegis cruiser conducts the intercept without ever acquiring the target field on organic radar, which under any circumstances is less capable than the XBR in performing discrimination functions. This significantly degrades discrimination capability because the decoys must simulate the actual warhead in only one spectrum, IR, in order to confuse the seeker. Utilizing multiple spectra significantly increases decoy

discrimination and, in order to be effective, greatly increases the complexity of the decoys.

The EKV is also much more capable than the LEAP in performing target discrimination. The EKV utilizes both an optical telescope and multiple wavelength IR sensors as opposed to the single wavelength seeker on the LEAP.[198] This gives the land-based system data at four wavelengths in three spectrum, RF, IR and visual light, as opposed to only one or two spectrum, IR and possibly RF, for the sea-based system. The increased sensitivity of the EKV sensors with detection ranges as great as 1500km as opposed to 300km for the LEAP also provides significantly more time for the seeker to perform target discrimination.[199]

As was previously discussed in testing, the proposed land-based system has decoys included in every trial, however since it is currently designed against TBMs, which are less likely than ICBMs to carry decoys, testing against them is not currently included in the SM-3 test regime. In defending the land-based system's ability to defeat decoys against one of the numerous skeptics, John Peller, Boeing NMD Program Manager,

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[198] The seeker on SM-3 Block II missiles should have a multiple wavelength seeker. Grant, *Navy Theater Wide Brief*.

[199] During IFT-3 the EKV demonstrated both its ability to discriminate between a decoy and the reentry vehicle and the utility of having time to perform the discrimination function and adjust the intercept accordingly. In this flight test an improper star map was loaded into the EKV which did not allow it to accurately determine its position after separation form the booster and forced it to rely solely on its inertial navigation system which had experienced a slight amount of drift during the boost. Because of this the reentry vehicle fell outside of the field of view of the EKV, however a decoy balloon was at the edge of the field of view. The seeker correctly identified the decoy and continued searching for the reentry vehicle. Unable to locate the reentry vehicle the seeker locked on to the decoy and centered it in its field of view, which brought the reentry vehicle into the field of view. Upon spotting the reentry vehicle the EKV discarded the decoy locked onto the reentry vehicle and successfully killed it. As a result of this test, in addition to correcting the star map problem the search volume of the seeker was also increased to eliminate this problem in the future.

stated, “They don’t have my data, I think the system can handle them.”[200] It is unknown if the sea-based system can.

Security: Score One for Sea-Based

One issue that has not been discussed previously in this paper is the physical and electronic security of the two competing systems. This is once more a critical issue because without every individual part of the NMD system working the system as a whole may fail. In that regard, to make the system fail does not require physical destruction or even an extended disruption of the entire system but only a limited attack against a single key component. As a number of the components of the two systems are the same, they will have identical security requirements. However, different components may be more vital to one system or another. Also, the security for the Aegis cruisers will be significantly different and their security concerns will vary greatly depending on whether they are forward deployed attempting ascent phase intercepts, on the open ocean countering a sea-launch threat, or in U.S. coastal waters providing late midcourse defense.

First let us consider the SBIRS system. Although beyond the current technical means of most nations, this system could be defeated in a number of ways including ground-based lasers used to either blind or permanently damage the satellites, kinetic anti-satellite weapons (interceptors or space mines), or electronic jamming of communications to or from the satellites. While the SBIRS is the same for both of the proposed systems, the consequences are much higher for the sea-based system. Disruption of this system would be a mission kill for the sea-based system, which is

[200] John Peller, Boeing NMD Program Manager quoted, in Dornheim, “National Missile Defense Focused

entirely dependent on the SBIRS-Low for cueing, while due to the greater capability of its sensors; the land-based system would retain some capability.

Next let us consider the BM/C3 system as a whole. In order to function properly the system will require large bandwidth communication among all of its dispersed elements. For the land-based system this would include the Command Center at Cheyenne Mountain, the interceptor site most likely in Alaska, the XBR site at a different location in AK, UEWRs located around the world, IFICS at multiple locations and communications with DSP or SBIRS. For the sea-based system it would include the Command Center at Cheyenne Mountain, all of the Aegis cruisers performing NMD, and the SBIRS. Except for communication with the SBIRS the primary means of communication for the land-based system would be via fiber optic cable with satellite communications as a back-up. The sea-based system would be entirely reliant upon satellite communications. While this is a very subjective assessment as to which of these systems is the more reliable, it would appear the land-based system with redundant communication methods, and a fixed number of sites all dedicated solely to NMD would be preferable to the strictly satellite based communications to a varying number of multi-mission platforms which may or may not have NMD as their number one priority.

An equally subjective issue will be the discussion of the merits of the physical security of land-based installations as opposed to their sea-based counterparts. Under most circumstances the open ocean makes U.S. warships invulnerable to attack from most nations and relatively immune to attack from even Russia or China. The one exception to this rule would be for cruisers attempting to conduct ascent phase intercepts when they would be required to be relatively close to the coast of the threat nation and

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on June Review."

certainly within range of land-based aircraft capable of carrying anti-ship missiles, as well as enemy surface craft. Many rogue nations that are developing ballistic missiles, including North Korea and Iran, are also acquiring very capable submarines, which could prove to be a threat to Aegis cruisers attempting to perform ascent phase NMD. The level of this threat has recently increased with the sale of Soviet Sovremenny class destroyers capable of firing Sunburn anti-ship missiles to China and the prospect that proliferation of this type of extremely capable anti-ship missile will continue.[201] For the land-based system, the interceptor field and command and control system itself would be in underground silos much like our current ICBM systems and, as such, would be a very hard target relatively immune from physical attack. It would, however, be more difficult to harden the large XBR, IFICS and UEWR complexes and these sites could possibly be subject to either conventional or terrorist attack, keeping in mind that the site would not have to be destroyed but only their operations disrupted for a few key minutes during the attack.

Although some components are still vulnerable the overall security assessment would have to favor the sea-based option primarily due to the large number of remote land-based facilities and the difficulties in hardening large radar arrays. The sea-based system also offers the advantage of redundancy whereas there are many single sources of failure in the land-based system. Achieving this redundancy may come at the cost of dedicating more naval assets than have previously been discussed.

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[201] The Sunburn is an extremely capable Russian supersonic anti-ship missile specifically designed to defeat Aegis cruisers. "SS-N-22 Sunburn (P-80/3m-80 Zubr)," Jane's Strategic Weapons Systems, vol. 29, 28 January 1999.

Command and Control/Concept of Operations: Sea Has No Game Plan

The command and control segment is being presented last because to truly appreciate the complexities of managing the system, a thorough understanding of all of the components that must be tied together is critical. The discussion of the command and control element of the NMD system will be broken into two segments, technical issues and concept of operations issues, each one presenting its own unique challenges.

The technical requirements for the BM/C3 system were explained in chapter four and included quite an extensive list of capabilities the system must possess. For the proposed land-based system this BM/C3 component has been under development since the mid-1990s. Although still not complete, the BM/C3 system was for the first time successfully tested in January 2000 during IFT-4.[202] While the BM/C3 system has been scaled down from what would have been required to defend against an all-out Russian attack, its complexity should still not be underestimated.[203] To make the BM/C3 system work for the proposed sea-based system would require extensive modification to the software. There would be the addition of multiple new sensors, which are already capable of developing a netted theater wide radar picture via CEC or TADIL-J. Instead of a single fixed interceptor site there would now be a variable number of mobile interceptor sites and the interceptors may be capable of either ascent or midcourse intercept. There would be the possibility of multiple platforms capable of conducting

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[202] Although the intercept failed due to mechanical problems onboard the EKV, all data indicates the BM/C3 system functioned correctly during this flight test. Senior Military Official, "Ballistic Missile Intercept Test," Background briefing, 19 January 2000, URL <www.defenselink.mil> accessed 21 January 2000.

[203] When the BMC3 system was being developed for the SDI program it was thought to be one of the most complex computer systems ever created and its complexity was on the same scale as that required to operate the entire U.S. telephone system. As such there were many doubts that it could be developed and adequately tested.

either of the types of intercept. The BM/C3 system would be required to continuously maintain the status of each of those platforms and the missiles and sensors on board.

While the additional code for the NMD system could certainly be developed and, if required, computing capacity could be increased, none of this groundwork has been performed. Much as software integration problems are delaying the NAW system, this issue alone could make the proposed sea-based system non-competitive with the land-based-system in regards to deployment timeframe. What may be more difficult and expensive than the software modifications to the already developed portion of the BM/C3 system is the integration of the NMD software on the Aegis cruisers. This presents multiple concerns. Because the AWS is multi-mission software, integration of each new segment becomes more difficult. While it is currently being upgraded, there is limited computing power within the AWS and this must be shared with other mission areas. Just as with the SM-3 missile, because this is being incorporated onboard an existing system, there is limited space for expansion to add increased capability. These modifications also become more expensive and time consuming because instead of modifying a single ground based site, all 22 Aegis cruisers would need to be modified.

The complexities of the BM/C3 system are not limited to technical issues. When developing a command and control system, doctrine, concept of operations, and chain of command issues must all be worked out concurrently with the technical, systems and equipment issues. As an example of the complexity, time and difficulty involved in completing the doctrine part of this equation, *Joint Doctrine for Countering Air and*

Missile Threats, which deals primarily with the roles surface and air force commanders play in countering theater missile threats, was in coordination for nearly four years.[204]

The Concept of Operations issues would be exponentially more complicated for NMD for several reasons. Whereas when conducting joint TBM operations all assets would belong to a single CINC who could organize and direct subordinate units in accordance with his desired plan, the elements involved in sea-based NMD could fall under three or more CINCs.[205] This complicated command structure would be a marked disadvantage versus the land-based system, which would fall under the control of a single CINC.

In discussing command and control, the primary mission of the Aegis cruiser, defending the carrier battle group (CVBG), must also be considered. The CVBG defense mission has already been infringed upon by the requirement for the Aegis cruisers to be Tomahawk shooters and will be further infringed upon as they are required to begin taking on the TBMD mission. The increased requirements being levied upon the Aegis cruisers, diverting them from their primary mission, has already caused the Navy to request and most likely be authorized additional Arleigh Burke destroyers, at nearly $1 billion a copy, for CVBG protection.[206] With or without these additional assets however, it is still within the purview of a single CINC to organize their forces to accomplish the stated mission. When yet one more mission is levied upon the limited number of Aegis cruisers and they are also required to perform the NMD mission, command of those keys

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[204] Richard Lardner, "Joint Staff Gets Closer to Settling Air, Missile Defense Doctrine Debate," *Inside The Pentagon*, February 4, 1999.
[205] Depending on how the Concept of Operation and Concept of Employment are developed CINCSPACE, CINCSTRAT and one or more regional CINCs could all be involved in providing components of the sea-based NMD system.
[206] Holzer, "U.S. Navy Hopes to Expand Fleet."

assets will elevate above the CINC and becomes a national level issue. If the Aegis cruisers do become national assets, possibly assigned to CINCSTRAT as their deterrent counterparts are, then their ability to respond to their traditional taskings would certainly be in question. If the Aegis cruisers continue to operate as multi-mission platforms, as designed, this too would make them less capable NMD platforms then the land-based system which is entirely dedicated to NMD.

If solving the command and control or the over tasking issue in order to provide sea-based NMD requires the construction of new platforms, then a very close look must be taken at the utility of sea-based NMD and the ramifications of adding this mission to the Aegis cruisers. If it is determined that a sea-based NMD capability is desired for the benefits this type of mobile defense could provide, then all of the possible sea-based alternatives should be reviewed.

Scorecard

Although not each of the following categories should be weighted equally nor is the decision decisive in all cases, Table 23 demonstrates that the land-based system edges out the sea-based system in most of the areas analyzed.

Table 23: The Scorecard

Event	**Team Land**	**Team Sea**
Sensor Performance	X	
Booster Performance	X	
Kill Vehicle Performance	X	
The Timeline	X	
Programmatic Risk		X
Testing	X	
Cost	X	
Technical Hurdles	X	X
Capabilities against the Threat	X	
Defended Area	X	
P(k) Considerations	X	
Countermeasures	X	

Security		X
Command and Control/Concept of Operations	X	

Chapter 7

The Bottom Line

A comparison of the two systems has proved to be an immensely difficult undertaking. The scope of the analysis is extremely broad and the amount of material on the subject immense. That said, in some areas there is not sufficient data available to make an absolute determination, and in other cases it was required to make a conscious choice among conflicting data. While The Heritage Foundation continues to make audacious claims about the ability to field the sea-based system quickly and cheaply, very little concrete data was available to support those claims, resulting in a relatively unfavorable assessment of their proposal. With that in mind, based on the preceding evaluation and analysis, the following conclusions and recommendations are provided.

Conclusions

- The proposed land-based system could be fielded faster than any sea-based system with similar capabilities. However, it is unlikely that the land-based system can be fielded as currently planned by late FY05.
- The proposed land-based system will be able to meet the specified requirements for NMD at the three currently specified capability levels. While it is unlikely it would ever be able to be expanded to blunt a major Russian attack, the proposed land-based system is expandable to meet larger and more advanced threats.

• The NAW and NTW Block I will have no capability against ICBMs and there is not currently any defined or funded program that would give sea-based missile defense systems the capability to defend the United States against ICBMs. However, with the addition of external sensor data and upgrades beyond the Block II capability, the NTW system could possess significant NMD capabilities.

• Though technically possible to expand NTW into a sea-based NMD system, even with an accelerated schedule this capability will not exist until after FY10.

• The current Aegis Weapon System could serve as a springboard for future sea-based missile defense systems, however many of the components would need to be replaced or significantly upgraded. Modifications would need to be made to the AWS software and additional communications capabilities would be required. The current radar is inadequate and collocation of the radar and launcher is less than ideal for NMD functionality. The current missile has insufficient V(bo) and although a larger and more capable version of the SM-3 could be built, this is a significant undertaking. Depending on the degree to which the missile was expanded modification of the Mk 41 VLS might also be required. With these limitations in mind and together with the significant command relationship, concept of operations and concept of employment issues, an option other than Aegis might be a better long-term solution for sea-based NMD.

• Any sea-based system would rely heavily on the same external sensors, ground-based radar and SBIRS, and BM/C3 system as the proposed land-based system. As such the proposed sea-based system in fact only replaces one of the four elements of the current land-based proposal, the interceptor itself. All other components would still be required.

- Due to the specific stationing requirements essential for sea-based missile defense, it is not an efficient use of assets to utilize very expensive multi-mission ships such as Ticonderoga class cruisers and Arleigh Burke class destroyers for this mission.

- Neither of the proposed systems is capable of defending the United States from all ballistic missile threats. Either system could be overwhelmed by a relatively small number of missiles, particularly in the C-1 and C-2 configurations. Due to the shorter range and reduced time of flight of sea-launched ballistic missiles, the land-based system would be incapable of intercepting them. While the proposed sea-based system would be capable of this type of intercept, it is unlikely that sufficient sea-based assets would be continuously available or properly positioned to constantly defend the United States against this threat. These missiles could currently be launched from improvised surface ships and countries other than Russia and China may obtain a submarine capability in the future.

- A sea-based system would be complementary to a land-based system and would provide additional security in several ways. The sea-based system, if properly positioned, would counter the threat of shorter-range missiles launched at the United States from submarines or surface ships. It would allow the BMD to be weighted against a specific threat. It would be able to extend BMD to areas beyond the range of our land-based system. It would increase the overall effectiveness of the NMD system by providing multiple engagement opportunities for ICBMs launched at the United States. Finally, a sea-based system would provide redundancy to the proposed land-based system.

- The Heritage Foundation has provided a service by focusing attention on the need for national missile defense and bringing to light the capabilities and advantages of sea-

based missile defense. However their assessment that a sea-based system would be as capable as the proposed land-based system or that it could be deployed faster and more cheaply is incorrect.

Recommendation

A strong national defense is in the best interests of the United States. While immune to invasion and most other forms of attack, the United States is vulnerable to ballistic missile attack and grows more so every day. It is indeed unlikely that a country would launch an unprovoked attack on this country, however the threat of an attack has the potential to limit our freedom of action and options for responding to international crises. It is primarily for this reason that we must deploy a NMD system to ensure our ability to respond to threats around the world. And it is essential that the deployed NMD system be capable of dealing with the entire range of ballistic missile threats; thus it should not be a question of either a land-based system or a sea-based system. In order to provide a comprehensive defense, both systems are needed and even this combined defense will unfortunately have holes in it which future systems will need to be developed to counter.

In spite of The Heritage Foundation's contentions, the United States is doing just that. Although it is unlikely that the land-based NMD system can be fielded as planned by the end of 2005, it is very likely that within the decade a highly reliable system will be in place to defend the United States from a limited or accidental ballistic missile attack. And although there is no official program established yet, as has been discussed, it is impossible to build the NTW system so that it does not have the potential to have some NMD capability. That potential will be realized with the faster Block II interceptor, an improved radar and integration with the land-based systems sensors. All of the activities

are being explored if not already acted upon. The development of this capability will not happen by 2003, it will not happen by 2005, and it won't happen as fast as the land-based system, but it will happen.

Given that there are clear advantages to both land-based and sea-based systems, the most logical decision would be to proceed along the path we are on (although not yet officially) with the development of both systems. This would most likely mean providing protection for the majority of the United States by means of a land-based system at one or multiple sites. In order to proceed down this path however, the ABM treaty restrictions on both the land-based and sea-based systems need to be overcome. It must be acknowledged that a multi-level system is being developed and the sea-based NMD capabilities should not be allowed, as they currently are, to develop by default. A plan must be implemented for the combined system optimizing each component for those threats to which it is best suited and offers the most unique capabilities.

Following this course of action will provide the United States with a more robust ballistic missile defense capability and it will in fact not cost significantly more than is currently being spent. It will bring these systems online along their currently programmed timeline, and in addition, only the capabilities of the systems will have been developed and integrated to provide a superior NMD system. With this schedule there will be a short window of vulnerability during which our NMD capabilities are not adequate against all threats. This is an unfortunate occurrence, which had different decisions been made in the early 90s, possibly could have been avoided. However, now we need to avoid the "rush to failure" referred to so many times by General Welch in his two reports on ballistic missile defense and develop the NMD system which best defends

the United States in a technically, programmatically and fiscally sound manner. This requires the land-based system be deployed first, and sea-based NMD capabilities to strengthen the system as they become available.

Finally it should be noted that in addition to the technological and financial challenges of developing any NMD system, less tangible elements such as political leadership and will, overall economic strength and diplomatic power all play an indirect but not insignificant role in determining the quality of our national defense. And if we fail in these other areas it will be very difficult for hardware alone to secure our borders.

Appendix A

Countries Possessing Ballistic Missiles

Country	**Missile**	**Category**	**Range (km)**	**Status**	**Remarks**
Afghanistan	SCUD B	SRBM	300	Retired	
Algeria	FROG-7B	SRBM	70	Operational	
Argentina	Alacran	SRBM	150	Operational	
Belarus	SCUD B	SRBM	300	Operational	
	SS-21	SRBM	70	Operational	
Brazil	SS-300	SRBM	300	CANX	
	SS-600	SRBM	600	CANX	
	MB/EE-350	SRBM	350	CANX	
	MB/EE-600	SRBM	600	CANX	
	SS-1000	MRBM/IRBM	1200	CANX	
	VLS	SLV	5000	Development	
Bulgaria	SCUD B	SRBM	300	Operational	
	SS-23	SRBM	500	Operational	
Chile	Rayo	SRBM	30	Operational	
China	CSS-6 (DF-15/M9)	SRBM	600	Operational	
	CSS-7 (DF-11/M11)	SRBM	280	Operational	
	CSS-8 (M7-8610)	SRBM	150	Operational	
	CSS-5 Mod 1(DF-21)	MRBM/IRBM	1700/ 1800	Operational	
	CSS-5 Mod 2	MRBM/IRBM	1700/ 1800	Operational	
	M-18	MRBM/IRBM	1000	Unkown	
	(DF-25)	MRBM/IRBM	1700	Development	
	CSS-2 (DF-3)	ICBM	2400	Retired	
	CSS-2 (DF-3A)	ICBM	2400	Retired	
	CSS-3 (DF-4)	ICBM	4750	Operational	
	CSS-4 Mod 1(DF-5)	ICBM	12,000	Operational	
	CSS-4 Mod 2(DF-5A)	ICBM	13,000	Operational	
	CSS-X-9 (DF-31)	ICBM	8000	Development	
	CSS-X-10 (DF-41)	ICBM	12,000	Development	
	CSS-N-3 (JL-1)	SLBM	1700	Operational	
	CSS-NX-5 (JL-2)	SLBM	8000	Development	
Cuba	FROG-7B	SRBM	70	Operational	
Egypt	SCUD B	SRBM	300	Operational	

Country	Missile	Category	Range (km)	Status	Remarks
	VECTOR			CANX	Condor II (Argentina), Vector (Egypt) and Badr 2000 (Iraq) all the same missile
	Project T		450	Operational	Enhanced SCUD
France	M-4	SLBM	4000	Operational	
	M-45	SLBM	6000	Operational	
	M-51	SLBM	10,000	Development	
India	Prithvi SS-150	SRBM	150	Operational	
	Prithvi SS-250	SRBM	250	Operational	
	Prothvi SS-350	SRBM	350	Development	
	Sagarika	SRBM	240	Development	
	Agni	MRBM/IRBM	2000	Development	
	Agni follow on	MRBM/IRBM	>2000	Development	
	Surya	SLBM	12,000	Development	
Iran	Iran-130 (Mushak 120)	SRBM	130	Operational	
	CSS-8 (M7)	SRBM	150	Operational	
	SCUD B	SRBM	300	Operational	
	Shahab-2 (SCUD C)	SRBM	550	Operational	
	Shahab-3 (Zelzal)	MRBM/IRBM	1300	Development	Nodong derivative
	Shahab-4	MRBM/IRBM	>2000	Development	Nodong derivative
Iraq	Ababil-100	SRBM	100	Unkown	
	Al Samoud	SRBM	90	Development	
	SCUD-B	SRBM	300	Unkown	
	Al Hussein	SRBM	650	Operational	
	Al Hijarah	SRBM	750	Unkown	
	Al Abbas	SRBM	900	Unkown	
	Badr-2000	SRBM		CANX	
	Al Aid (Tammuz-2)	MRBM/IRBM	3000	Unkown	
Israel	Jericho 1 (YA-1)	SRBM	500	Operational	
	Jericho 2 (YA-3)	MRBM/IRBM	1500	Operational	
	Jericho 3 (YA-4)	MRBM/IRBM	4800	Development	
Kazakhstan	SCUD B	SRBM	300	Operational	
	SS-21	SRBM	120	Operational	
Libya	SS-21	SRBM	120	Operational	
	SCUD-B	SRBM	300	Operational	
	SCUD-C	SRBM	550	Operational	
	Al Fattah	SRBM	950	Development	
North Korea	SCUD B	SRBM	300	Operational	
	Hwasong-5	SRBM	330	Operational	SCUD-B derivative
	Hwasong-6 (SCUD C)	SRBM	500	Operational	
	No Dong 1	MRBM/IRBM	1000	Operational	
	No Dong 2	MRBM/IRBM	1500	Development	
	Taepo Dong 1	MRBM/IRBM	2000	Development	
	Taepo Dong 2	MRBM/IRBM	3500	Development	
Pakistan	Hatf-/1A1	SRBM	80-100	Operational	

Country	Missile	Category	Range (km)	Status	Remarks
	Hatf 2	SRBM	300	Operational	
	Haft 3	SRBM	600	Unkown	M-9 derivative
	Haft 4	SRBM	280	Development	M-11 derivative
	Hatf-5	MRBM/IRBM	1500	Development	Nodong-1 derivative
	Shaheen-II	MRBM/IRBM	2000	Development	Nodong-2 derivative
	Abdali	MRBM/IRBM	2500	Development	Nodong-2 derivative
Russia	FROG-7B	SRBM	65	Operational	
	SS-1B (SCUD A)	SRBM	180	Operational	
	SS-1C (SCUD B)	SRBM	300	Operational	
	SS-1D (SCUD C)	SRBM	550	Unkown	
	SS-1E (SCUD D)	SRBM	300	Unkown	
	SS-21(Scareb B)	SRBM	70	Operational	
	SS-23 (Spider)	SRBM	500	Operational	
	SS-X-26	SRBM	400	Development	
	SS-18 Mod 4 (Statan)	ICBM	8800	Operational	
	SS-18 Mod 5	ICBM	9600	Operational	
	SS- 19 Mod 3 Stiletto)	ICBM	8800	Operational	
	SS-24 Mod 1(Scalpel)	ICBM	10,000	Operational	
	SS-24 Mod 2 (Scalpel)	ICBM	8800	Operational	
	SS-25 (Sickel)	ICBM	10,500	Operational	
	SS-27(Topol-M)	ICBM	10,500	Operational	
	SS-N-6	SLBM	2400	Operational	
	SS-N-8 (Sawfly Mod 1)	SLBM	7800	Operational	
	SS-N-8 (Sawfly Mod 2)	SLBM	9100	Operational	
	SS-N-18 (Stingray)	SLBM	6500	Operational	
	SS-N-20 (Sturgeon)	SLBM	8300	Operational	
	SS-N-23 (Skiff)	SLBM	8300	Operational	
	SS-N-28	SLBM	8000	Development	
Saudi Arabia	CSS-2 (DF-3A)	MRBM/IRBM	2400/ 2800	Operational	
Slovakia	SS-21	SRBM	120	Operational	
	SS-23	SRBM	500	Operational	
South Africa	Arniston	MRBM/IRBM	1450	Test Flown	
South Korea	NHK-1	SRBM	180	Operational	
	NHK-2	SRBM	260	Operational	
Syria	SCUD B	SRBM	300	Operational	
	SCUD C	SRBM	550	Operational	
	SS-21	SRBM	120	Operational	
Taiwan	Green Bee (Ching Feng)	SRBM	130	Operational	
	Sky Horse (Tien Ma)	SRBM	950	Development	
Turkmenistan	SCUD B	SRBM	300	Operational	
Ukraine	SCUD B	SRBM	300	Operational	
	SS-21	SRBM	120	Operational	
Vietnam	SCUD B	SRBM	300	Operational	
Yemen	SCUD B	SRBM	300	Operational	

Sources: National Air Intelligence Center, *Ballistic and Cruise Missile Threat*, NAIC 1031-0985-98 URL <www.fas.org/irp/threat/missile/naic> accessed 30 June 1999; Federation of American Scientists, "Missile Proliferation: From A (Afghanistan) to Almost Z (Yemen)," URL <www.fas.org/irp/threat/missile/intro.htm> accessed 30 June 1999; CDISS, "Missile Resources: National Briefings," URL www.cdiss.org, accessed 22 June 1999.

Legend

SRBM	Short-Range Ballistic Missile	<1000km
MRBM	Medium-Range Ballistic Missile	1000-3000km
IRBM	Intermediate-range Ballistic Missile	3000-5000km
ICBM	Intercontinental Ballistic Missile	>5000km
SLBM	Submarine Launched Ballistic Missile	
SLV	Space Launch Vehicle	

Appendix B

Testing Schedules

Navy Area Wide

Test	Date	Status	Remarks
CTV-1	Aug-99		Developmental Testing/Operational Assessment at White Sands Missile Range. 8 test events.
CTV-2	Feb-00		
Fly-By	Aug-00		
TBM-1	Oct-00		
TBM-2	Dec-00		
AAW	Jan-01		
TBM-3	Apr-01		
TBM-4	Jul-01		
LB at Sea	Aug-01		Linebacker at sea testing. 3 test events with 3 SM-2 Blocl IVA missiles vs 4 TBM targets.
DT/OT	May-Nov-02		Developmental Testing/Operational Testing at Pacific Missile Range Facility. 25 Test events. 16 TBM, 9 AAW.

Navy Theater Wide

Test	Date	Status	Remarks
FTV-1	Sep-92	Fail	Modified Terrier/LEAP fired from USS Richmond K. Turner
FTV-2	Sep-93	Fail	LEAP/SM-2 Block III from USS Jouett
FTV-3	Mar-95	Fail	LEAP from USS Richmond k. Turner
FTV-4	Mar-95	Fail	LEAP from USS Richmond k. Turner
CTV 1A	24-Sep-99	Pass	Control Test Vehicle. Non Intercept. Airframe performance, booster sep, guidance and control. Launched from Shiloh.
TTV-1	18-Nov-99	Pass	Test Target Vehicle. No launch. Tested ability to track and develop fire control solution on TTV
FTR-1	2Q FY00		DT-1A Series Next Test
FTR-2	3Q FY00		
FTR-3	4Q FY00		First Scheduled Intercept test
FTR-4	1Q FY01		
FTR-5	2Q FY01		
FTR-6	3Q FY01		
FTR-7	4Q FY01		

FTR-8	1Q FY03		DT-1B Series. Target Representative Test. Descent Engagement Test
FTR-9	2Q FY03		Target Representative Test. Descent Engagement Test
FTR-10	3Q FY03		Target Representative Test. Descent Engagement Test
FTR-11	3Q FY03		Target Representative Test. Ascent Engagement Test
FTR-12	4Q FY03		Target Representative Test. Ascent Engagement Test
FTR-13	4Q FY03		Target Representative Test. Ascent Engagement Test
DT/OT	FY06-07		EMD includes 20 Missile Firings

THAAD

Test	**Date**	**Status**	**Remarks**
FT-01		Pass	Non Intercept. Propulsion
FT-02		Fail	Non Intercept. Controllability. Range Safety Termination
FT-03		Fail	Non Intercept. Target not designated. FPA edge Saturation.
FT-04	1995	Fail	Exo Intercept. DACS Fuel Depleted. Software Error in IFTU Logic.
FT-05	1995	Fail	High Endo Intercept. Separation Anomaly. Connector Failure.
FT-06	15-Jul-96	Fail	High Endo Intercept (Repeat 5) Seeker Electronics malfunction
FT-07	06-Mar-97	Fail	High Endo Intercept. DACS Anomaly. Cable electrical problem.
FT-08	12-May-98	Fail	High Endo Intercept. Boost Controllability Loss. Thrust vector control failure
FT-09	29-Mar-99	Fail	Attempted to intercept HERA Tgt missile.
FT-10	10-Jun-99	Pass	Body to Body intercept test. HERA Tgt missile launched 120 Miles away intercept at an altitude of almost 60 miles. Endo Atmospheric. Unitary Tgt.
FT-11	02-Aug-99	Pass	Intercepted HERA Tgt Missile. Exo Atmospheric. Separating tgt.
FT-12	19-Aug-99	CANX	Test canceled due to missile advancing to Engineering Manufacturing Development (EMD)
FT-13		CANX	Test canceled due to missile advancing to Engineering Manufacturing Development (EMD)
EMD Tests	4Q2004		35-40 EMD tests to be conducted. With simulations and hardware in the loop simulations. DOT&E wants 5 pre EMD Tests under more realistic conditions prior to going to EMD.

National Missile Defense

Test	**Date**	**Status**	**Remarks**
IFT 1	01-Jan-97		Payload Launch Vehicle failed. Test aborted.
IFT 1A	23-Jun-97	Pass	Sensor Flight Test. Sensor technology and performance. Non-intercept fly by test designed to assess EKV seeker discrimination and homing algorithm. Boeing EKV.
IFT 2	16-Jan-98	Pass	Sensor Flight Test. Sensor technology and performance. Non-intercept fly by test designed to assess EKV seeker discrimination and homing algorithm. Raytheon EKV.
IFT 3	2-Oct-99	Pass	EKV intercept flight testing. Evaluate discrimination and intercept of RVs by kill vehicles. First attempt at intercepting a threat representative ICBM target. Target launched from Vandenburg. Interceptor launched from Meck Island, Kwajalein Atoll. 4200 mile test. IFT 3 and IFT 4 were supposed to use Boeing and Raytheon EKV's. Decision to down select to one EKV prior to test 3. Raytheon EKV selected. DSP satellites, GBR at Kwajalein, upgraded early warning radar at Beale AFB, Calif., and BM/C3 in "shadow" mode—actively viewing and computing but not controlling the intercept. Target cluster included the RV and a single decoy balloon. Simulated radar track date provided by GPS receiver on tgt and C-band radar beacon.

IFT 4	18-Jan-00	Fail	EKV intercept flight testing. Evaluate discrimination and intercept of RVs by kill vehicles. All Components except DSP and IFICS, which are still in "shadow mode." Same decoy as IFT-3. Failed to intercept due to a IR seeker cooling system problem. All other systems appeared to operate correctly.
IFT 5	26 Jun-00		First integrated system test. Will evaluate NMD system performance. System alerted by DSP. IFICS will transmit data. Same target set as IFT 4.
IFT 6	Jul-00		Repeat of IFT 5. Same target set as IFT 4 and 5.
IFT 7	2Q FY01		First Test with actual booster all previous tests use Minuteman III "payload Launch Vehicle." Counter measures sophisitcation increased to a "more complex rogue threat" that is still C-1 type.
IFT 8	3Q FY01		All test through IFT-7 use rogue nation type countermeasures.
IFT 9	4Q FY01		
IFT 10	1Q FY02		
IFT 11	2Q FY02		
IFT 12	3Q FY02		
IFT 13	1Q FY03		Operational EKV
IFT 14-21	3Q FY03 to		Complete EMD, produce prime system components. Complete IOT&E
			3 Booster verification tests planned Mar 2000-2001

Appendix C

Members of The Heritage Foundation Team B Study Group and Commission on Missile Defense

Chairman
Ambassador Henry Cooper, former Director of the Strategic Defense Initiative Organization and Chief Negotiator to the Geneva Defense and Space Talks with the Soviet Union and Chairman of High Frontier

Members
Lieutenant General James A. Abrahamson, USAF (Retired), former Director of the Strategic Defense Initiative Organization and Associate Administrator of the National Aeronautics and Space Administration

The Honorable Frank Gaffney, former Acting Assistant Secretary of Defense for International Security Policy and Director, Center for Security Policy

Dr. Edward T. Gerry, former Acting Deputy Director of the Ballistic Missile Defense Organization and SDI/BMDO Systems Architect

Lieutenant General Daniel O. Graham, USA (Retired), former Deputy Director of Central Intelligence and Director of The Defense Intelligence Agency

The Honorable William R. Graham, former Director of the White House Office of Science and Technology Policy and Science Advisor to President Ronald Reagan, former Deputy Administrator of the National Aeronautics and Space Administration, and former Chairman of the Strategic Defense Initiative Advisory Committee

Dr. Michael Griffin, former Deputy Director for Technology for the Strategic Defense Initiative Organization and Assocaite Administrator of the National Aeronautics and Space Administration

Dr. Jack Hammond, former Director of Directed Energy SDI Programs and Assistant Director of SDI Kinetic Energy Programs

General Charles Horner, USAF (retired), former Commander in Chief, U.S. Space

Command

Dr. Fred C. Ikle, former Undersecretary of Defense for Policy and Director of the Arms Control and Disarmament Agency

Sven F. Kraemer, former Director of Arms Control on the National Security Council Staff

The Honorable William Schneider, former Undersecretary of State and Chairman of the General Arms Control General Advisory Committee

General Bernard A. Schriever, USAF (Retired), former Commander of Air Force Systems Command and Member of the Strategic Defense Initiative Advisory Committee

Dr. William R. Van Cleave, Head of President Ronald Reagan’s 1980 Defense Transition Team and Advisor to the Secretary of Defense on the Strategic Arms Limitation Treaty

The Honorable Malcolm Wallop, former U.S. Senator from Wyoming

The Honorable Vin Weber, former U.S. Representative from Minnesota

Vice Admiral J. D. Williams, USN (Retired), former Director of Naval Warfare, Commander of the Sixth Fleet, and Member of the Ballistic Missile Defense Organization Advisory Group

Glossary

ABM	Anti-Ballistic Missile
ALERT	Attack and Launch Early Reporting to Theater
ALI	Aegis LEAP Intercept
AWACS	Airborne early Warning And Control System
AWS	Aegis Weapon System
BM/C3	Ballistic Missile Command, Control and Communications system
BMD	Ballistic Missile Defense
BMDO	Ballistic Missile Defense Organization
BMEWS	Ballistic Missile Early Warning System
C3	Command, Control and Communications
CEC	Cooperative Engagement Capability
CINC	Commander in Chief
COO	Concept of Operations
CVBG	Carrier Battle Group
DDR&E	Director Defense Research and Engineering
DOT&E	Director of Operational Testing and Evaluation
DRR	Deployment Readiness Review
DSP	Defense Support Program
DT	Developmental Test
EKV	Exoatmospheric Kill Vehicle
EMD	Engineering, Manufacturing Development
FTV	Flight Test Vehicle or Functional Technology Validation
FUE	First Unit Equipped
GBI	Ground Based Interceptor
GPALS	Global Protection Against Limited Strike
HTK	Hit To Kill
ICBM	Intercontinental Ballistic Missile
IFICS	Interceptor In-Flight Communications System
IFT	Integrated Flight Test
IGT	Integrated Ground Test
IOC	Initial Operational Capability
IR	Infrared
JTAGS	Joint Theater Air Ground System
LEAP	Lightweight Exoatmospheric Projectile
M3P	Multi-Mission Mobile Processors
MCS	Mission Control Station
MCSB	Mission Control Station Backup

MIRV	Multiple Independently targetable Reentry Vehicle
MSLS	Multi-Service Launch System
NAW	Navy Area Wide
NIE	National Intelligence Estimate
NMD	National Missile Defense
NTW	Navy Theater Wide
OT	Operational Test
P(k)	Probability of Kill
PLV	Payload Launch Vehicle
RCS	Radar Cross Section
SABMIS	Sea-Based Anti-Ballistic Missile System
SBIRS	Space-Based Infrared System
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization
SLBM	Submarine Launched Ballistic Missile
TADIL	Tactical Digital Link
TBM	Theater Ballistic Missile
THAAD	Theater High Altitude Air Defense
TOM	Target Object Map
UEWR	Upgraded Early Warning Radar
UOES	User Operational Evaluation System
V(bo)	Velocity at burn out
V(c)	Velocity of closure
VLS	Vertical Launch System
WMD	Weapons of Mass Destruction
XBR	X Band Radar

Bibliography

Barrie, Douglas. "British Mull U.S. Request for Missile Defense Site." *Defense News*, 31 January 1999, 1.

"Blair's Price: Protect Britain?" *Newsweek.* 7 February 2000.

CDISS. "Missile Resources: National Briefings." URL www.cdiss.org, accessed 22 June 1999.

Central Intelligence Agency. *Emerging Missile Threats to North America During the Next 15 Years*. NEI 95-19, November 1995, URL <www.fas.org/spp/starwars/offdocs/nie9519.htm> accessed on 22 November 1999.

Central Intelligence Agency, National Intelligence Council. *Foreign Missile Developments and the Ballistic Missile Threat to the United States Through 2015*. September 1999. URL <www.cia.gov/cia/publications/nie/nie99msl.html,>.

Cohen, William S. Annual Report to the President and the Congress. URL <www.dtic.mil/execsec/adr2000> accessed on 12 March 2000.

Congressional Office of Technology Assessment, *SDI: Technology Survivability and Software.* Springfield, VA. National Technical Information Service 1988. PB88-236245.

Cooper, Henry F. Former Director The Strategic Defense Initiative Organization, interviewed by author 3 March 2000.

Cooper, Henry F. "Unfinished Business." URL <www.highfrontier.org/UnfinshedBusiness.htm> accessed on 4 January 2000.

Davis, Richard, W. BGen, USAF, OSD, BMDO. Interviewed by author, 3 February 2000.

Department of Defense, Chairman Joint Chiefs of Staff. "Letter to Senator Inhofe." 24 August 1998. URL <www.clw.org/pub/clw/ef/shelton.html> accessed 23 June 1999.

Department of Defense. *Directive 5134.9: Ballistic Missile Defense Organization*. 14 June 94. URL <http://web7.whs.osd.mil/text/d51349p.txt> accessed 12 April 2000.

Department of Defense. "National Missile Defense Interceptor Booster Selected." OASD News Release 27 July 98. URL <www.defenselink.mil/news/jul1998/b07271998_bt398-98.html> accessed 15 November 1999.

Department of Defense. News briefing by Secretary of Defense William S. Cohen, Washington, DC, 20 Janauary 1999.

Department of Defense. *Report to the Congress on Navy Theater Wide Defense System (Formerly Navy Upper Tier).* 25 March 1996. URL <www.fas.org/spp/starwars/program/ntwd_960325.htm> accessed on 1 December 1999.

Department of Defense, Ballistic Missile Defense Organization. "BMDO RDT&E Budget Item Justification: PE 0603868C Navy Theater Wide-DEM/VAL." February 1999. URL <www.dtic.mil/comptroller/fy2000budget/index.html> accessed 12 April 2000.

Department of Defense, Ballistic Missile Defense Organization. "BMDO RDT&E Budget Item Justification: PE 0603871C NMD DEM/VAL," February 1999. <www.dtic.mil/comptroller/fy2000budget/index.html> accessed 12 April 2000.

Department of Defense, Ballistic Missile Defense Organization. *Ground Based Interceptor Sensor Flight Tests*. Fact Sheet, URL <www.acq.osd.mil/bmdo/bmdolink/pdf/jn9905.pdf> accessed on 18 March 2000.

Department of Defense, Ballistic Missile Defense Organization. *Missile Defense Milestones 1944 – 1997*. URL <www.acq.osd.mil/bmdo/bmdolink/html/milstone.html> accessed 30 November 1999.

Department of Defense, Ballistic Missile Defense Organization. *NMD Deployment Draft Environmental Impact Statement*. September 1999. URL <www.acq.osd.mil/bmdo/bmdolink/html/drafteis.html> accessed 12 April 2000.

Department of Defense, Ballistic Missile Defense Organization. *National Missile Defense Program*. Fact Sheet. March 1999. URL <www.acq.osd.mil/bmdo/bmdolink/pdf/jn9905.pdf> accessed on 18 March 2000.

Department of Defense, Ballistic Missile Defense Organization. "National Missile Defense Program Space and Missile Tracking System." URL <www.acq.osd.mil/bmdo/bmdolink/html/sbir.html> accessed on 16 June 1999.

Department of Defense, Ballistic Missile Defense Organization, "NMD Battle Management/Command, Control, and Communications (BM/C3)." URL <www.acq.osd.mil/bmdo/bmdolink/html/ccc.html> accessed 16 June 1999.

Department of Defense, Ballistic Missile Defense Organization. *Report to Congress on the Utility of Sea-Based Assets to National Missile Defense*. 1 June 1999, URL <www.acq.osd.mil/bmdo/bmdolink/pdf/seanmd.pdf> accessed 7 April 2000.

Department of Defense, Director of Operational Testing and Evaluation. *DOT&E FY96 Annual Report to Congress*. Washington, DC: February 1996, URL <www.dote.osd.mil/reports/FY96/96sbirs.html> accessed 30 March 2000.

Department of Defense, Director of Operational Testing and Evaluation. *DOT&E FY97 Annual Report to Congress*. Washington, DC: February 1997 URL < www.dote.osd.mil/reports/FY97/airforce/97sbirs.html> accessed on 30 November 1999.

Department of Defense, Director of Operational Testing and Evaluation, *DOT&E FY98 Annual Report to Congress*. Washington, DC: February 1998. URL < www.dote.osd.mil/reports/FY98/98tocmain.html> accessed on 7 July 1999.

Department of Defense, Director of Operational Testing and Evaluation. *DOT&E FY99 Annual Report to Congress*. Washington, DC: February 1999. URL <www.dote.osd.mil/reports/FY99/index.html> accessed 15 February 2000.

Department of Defense, National Security Space Roadmap Team. "Radiant Gold." URL www.fas.org/spp/military/program/nssrm/initiatives/rgold.htm

Department of Defense, Office of the Secretary of Defense. *Operations and Maintenance Overview: FY 2001 Budget Estimates*, March 2000. URL <http://www.dtic.mil/comptroller/fy2001budget/budget_justification/pdfs/operation/o_m_overview.pdf> accessed 16 April 2000.

Department of Defense, United States Air Force. *1997 United States Air Force Issues Book: Space Based Infrared System.* URL <www.af.mil/lib/afissues/1997/app_b_18.html> accessed on 22 June 1999.

Department of Defense, United States Air Force, Space and Missile Systems Center. *Space-Based Infrared System Handbook*. (Los Angeles, CA), 19, URL <www.laafb.af.mil/smc/mt/sbirs.htm> accessed 26 March 2000.

Department of Defense, United States Navy, N-86. "Navy Area Theater Ballistic Missile Defense and Linebacker." URL <http://surfacewarfare.nswc.navy.mil/n86/lib_navytbmd.html> accessed 9 Apr 2000.

Department of Defense, United States Navy. "The Status of the United States Navy." URL <www.chinfo.navy.mil/navpalib/news/.www/status.html.> accessed 10 April 2000.

Department of Defense, United States Navy. "The Carrier Battlegroup." URL <www.chinfo.navy.mil/navpalib/allhands/ah0197/cvbg.html.> accessed 10 April 2000.

Department of State. *Treaty Between the United States of America and the Union of Soviet Socialist Republics on The Limitation of Anti-Ballistic Missile Systems. 26 May 1972.* URL <www.state.gov/www/global/arms/> accessed 27 February 2000.

Department of State. "The Memorandum of Understanding Relating to the Treaty Between the United States of America and the Union Of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems of May 26 1972." 26 September 1997. URL <www.state.gov/www/global/arms/> accessed 27 February 2000.

Department of State. "The First Agreed Statement of September, 26 1997, Relating to the ABM Treaty." 26 September 1997. URL <www.state.gov/www/global/arms/> accessed 27 February 2000.

Department of State. "The Second Agreed Statement of September 26, 1997 Relating to the ABM Treaty." 26 September 1997. URL <www.state.gov/www/global/arms/> accessed 27 February 2000.

Department of State. "Agreement on Confidence Building Measures Related to Systems to Counter Ballistic Missiles Other Than Strategic Ballistic Missiles." 26 September 1997. URL <www.state.gov/www/global/arms/> accessed 27 February 2000.

Diamond, John. "Cost for Missile Defense Soaring." *Chicago Tribune*, 5 April 2000.

Donnelly, John. "Cost of Initial NMD to Rise 50 Percent." *Defense Week*, 20 Dec 99.

Dornheim, Michael A. "Missile Defense Design Juggles Complex Factors," *Aviation Week and Space Technology.* 24 February 1997, 56.

Dornheim, Michael A. "National Missile Defense Focused on June Review." *Aviation Week & Space Technology*, 16 August 1999, 66.

Dupont**,** Daniel G. "Administration Plans $2.2 Billion Increase for Expanded NMD Program." *Inside The Air Force*, 17 December 1999, 1.

Federation of American Scientists. "AN/FPS-115 PAVE PAWS Radar." URL <www.fas.org/spp/military/program/track/pavepaws.htm> accessed 1 December 1999

Federation of American Scientists. "AN/FPS-120 Solid State Phased-Array (SSPAR)." URL <www.fas.org/spp/military/program/track/clear.htm> accessed 1 December 1999.

Federation of American Scientists. “Ground Based Interceptor.” downloaded from www.fas.org/spp/starwars/program/gbi.htm, 1 December 1999.

Federation of American Scientists. “Ground Base Radar (GBR) X-Band radar (XBR).” URL <www.fas.org/spp/starwars/program/gbr.htm> accessed on 7 July 1999.

Federation of American Scientists. "Missile Proliferation: From A (Afghanistan) to Almost Z (Yemen)." URL <www.fas.org/irp/threat/missile/intro.htm> accessed 30 June 1999

Federation of American Scientists, “Space Based Infrared System,” URL <www.fas.org/spp/military/program/warning/sbir.htm> accessed on 19 February 2000.

Federation of American Scientists, “Space Based Infrared System,” URL <www.fas.org/spp/military/program/warning/smts.htm> accessed on 19 February 2000.

Federation of American Scientists. “Status of Nuclear Powers and Their Nuclear Capabilities.” URL <www.fas.org/nuke/guide/summary.htm> accessed on 27 March 2000.

Ferster, Warren “U.S. Testing Office Delays SBIRS Satellite Contracts.” *Defense News.* 12 July 1999, 4.

“First By Sea.” *Wall Street Journal*, 10 April 2000.

Fischer, Richard D. Jr., and Baker Spring, *China’s Nuclear and Missile Espionage Heightens the Need for Missile Defense.* Backgrounder, no. 1303. Washington, DC: The Heritage Foundation, 1999.

Gaffney, Frank J., Jr. “Anti-Missile Defense Dawdling.” *Washington Times*, 15 February 2000.

Gantz, M. “Navy Based National Missile Defense.” Brief presented by Draper Laboratory, 4 March 1999.

Gertz, Bill and Willis Witter. “U.S. Protests China’s Missile Help For North Korea.” *Washington Times*, 7 Jan 2000, Sec. A3.

Gertz, Bill. “U.S. Secrets Aboard Latest Chinese Sub.” *Washington Times*, 6 December 1999.

Glanz, James. “Flaws Found in Missile Test That U.S. Saw As a Success.” *New York Times*, 14 January 2000.

Graham, Bradley. "Missile Shield Still Drawing Friends, Fire." *Washington Post*, 17 January 2000, sec. A1.

Grant, P. M. III. Director, Navy Theater Wide Program, PMS 452, interviewed by author 3 March 2000.

Grant, P. M. III. "Navy Theater Wide Program Brief."

Harrison, Selig S. and Geoffrey Kemp. *India & America After the Cold War*. Carnegie Endowment for International Peace, 1993.

Heritage Foundation, The. *Defending America: A Plan to Meet the Urgent Missile Threat.* Washington, DC. The Heritage Foundation, 1999.

Heritage Foundation, The. *Defending America: A Near and Long Term Plan to Deploy Missile Defenses*. Washington, DC: The Heritage Foundation, 1995.

Heritage Foundation, The. *Defending America: Ending America's Vulnerability to Ballistic Missiles.* Washington, DC: The Heritage Foundation, 1996.

High Frontier. *Deception on Navy Theater Wide Costs*. Strategic Issues Policy Brief. 28 February 2000.

Hoffman, David. "Russia Test-Fires Interceptor Missile." *Washington Post.* 4 November 1999, Sec. A25.

Holzer, Robert. "Report: Sea-Land Combo Best NMD for U.S." *Defense News*, 6 September 1999, 3

Holzer, Robert. "U.S. Navy Hopes to Expand Fleet." *Defense News*, 31 January 2000, 31.

Hughes, David. "Battle Management Critical for Theater-Level Defense." *Aviation Week & Space Technology*. 3 March 97, 43.

Hughes Missile Systems Company. "Navy Leap Program Demonstrates Feasibility of Navy Theater-Wide TBMD." Fact Sheet. 1995. URL <www.fas.org/spp/starwars/docops/leap_test.htm> accessed on 19 January 2000.

Jungerman, John A. *The Strategic Defense Initiative: A Primer and Critique*. University of California Institute on Global Conflict and Cooperation, 1988.

Kandebo, Stanley W. "NMD System Integrates New and Updated Components." *Aviation Week & Space Technology*. 3 March 1997, 48.

LaCamera, Jerry. “Navy Area TBMD Overview.” Briefing presented to Potomac Institute, 4 May 1999.

Lardner, Richard. “Joint Staff Gets Closer to Settling Air, Missile Defense Doctrine Debate.” *Inside The Pentagon*, February 4, 1999.

Lee, William T. “Russian Sources Confirm Massive Soviet ABM Treaty Violations,” *The Shield*, vol. XVI no. 2 (March/April 1999).

Lee, William T. *The ABM Treaty Charade: A Study in Elite Illusion and Delusion.* Washington DC: Council for Social and Economic Research, 1997.

Lewis, George. *Chronology of Hit-to-Kill Missile Tests*. 6 April 1997. URL <http://www.fas.org/spp/eprint/lewis_tests.htm,> accessed 19 January 2000.

“Lightweight Exoatmosheric Projectile.” URL <http:/flthlpdsk.chinalake.navy.mil/help2/weapons/leap.htm> accessed 24 June 1999.

Lott, Trent, Jesse Helms et al. *Letter to the President*. 25 September 1998. URL <www.clw.org/pub/clw/coalition/helm0303.htm> accessed 26 February 2000.

MacDonald, D.H.L. “TBMD Could Backfire.” *Proceedings*. April 1998, 81-82.

Massachusetts Institute of Technology, Lincoln Laboratories. *BMD Briefing.* Presented to the Navy Missile Defense Data Collection Team, Arlington, VA, 5 March 1999.

“Navy Area Defense System: Interceptor Builds on Aegis Success.” *Air Defense Artillery Magazine Online*. URL <http://www.147.71.210.21/adamag/navy.htm> accessed on 22 June 1999.

National Air Intelligence Center, *Ballistic and Cruise Missile Threat. 1980*: NAIC-1031-0985-98. URL <www.fas.org/irp/threat/missile/naic/part06.htm> accessed on 30 June 1999.

“National Missile Defense Act H.R.4.” *Legislative Digest. URL <http://hillsource.house.gov/LegislativeDigest/ConferenceSummary/CSMain/cs106-3-MissileDefense.htm> accessed 16 April 2000.*

National Missile Defense Review. November 1999. URL <www.acq.osd.mil/bmdo/bmdolink/htmldocs.html> accessed 16 December 1999.

Natural Resources Defense Council. “US and USSR/Russian Strategic Offensive Nuclear Forces, 1945-1996.” URL <www.igc.apc.org/nrdc/nrdcpro/nudb/dainx.html> accessed 27 March 2000.

Northrup Grumman. "National Missile Defense Canister System Successfully Completes Development Test Milestone." Press Release. Baltimore, MD, 16 Aug 99.

Orman, Stanley. "Defeat of Missile Defenses Not as Simple as Portrayed." *Defense News*, 6 September 1999.

Ratnam, Gopal "NMD Could Get $2.2 Billion Windfall in 2001," *Defense News*, 21 February 2000, 26.

Reagan, Ronald. "Address to the Nation on Defense and National Security." 23 March 1983.

Reiss, Edward. *The Strategic Defense Initiative.* New York: Cambridge University Press, 1992.

Report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs. 27 February 1998. URL <www.acq.osd.mil/bmdo/bmdolink/pdf/welchrpt.pdf> accessed 11 April 2000.

Riley, Ben. Office of Naval Research, interviewed by author 6 December 1999.

"RIM-66/67/156 Standard and Standard SM-LEAP/SM-3." *Jane's Strategic Weapons System*, vol. 28, 7 Oct 98.

Rumsfeld, Donald. "Surprise, Surprise: When it Comes to Ballistic Missile Proliferation, Expect the Worst," *The Shield*, vol. XVI no. 1 (January/February 1999).

"Russia Growing Blind to Missiles." *Omaha World Herald*, 10 January 2000.

"SA-5 'Gammon' (S-200 Volga, 5V21/5V28)." *Jane's Strategic Weapons Systems*, vol. 30, 21 May 1999;

"SA-10 'Grumble' (S-300, S-300 PMU, Buk/Favorit/5V55/48N6)." *Jane's Strategic Weapons Systems*, vol. 30, 21 May 1999.

Sapolsky, Harvey M. *The Polaris System Development: Bureaucratic and Programmatic Success in Government.* Cambridge, MA: Harvard University Press. 1972.

Senior Defense Official. "National Missile Defense." Background Briefing. 14 January 2000. URL <www.defenselink.mil/cgi-bin/dlprint> accessed on 18 January 2000.

Senior Military Official. "Ballistic Missile Intercept Test." Background Briefing, 19 January 2000. URL <www.defenselink.mil> accessed 21 January 2000.

Schwartz, Stephen I. "Missile Defense." *Defense News*, 3 February 1997.

Scott, William B. "Congress Rips SBIRS Cutbacks." *Aviation Week & Space Technology*. 29 March 1999, 37.
Sharpe, Richard, eds. *Jane's Fighting Ships.* Surrey, UK: Jane's Information Group 1999.

Sims, Calvin. "South Korea Plans to Begin Rocket Program." *New York Times*, 15 January 2000.

Sloss, Leon and Seymour Weiss, "Strategic Defense: A Third View" in *The Technology, Strategy, and Politics of SDI*, ed. Steven J. Cimbala. Westview Press: Boulder, 1987.

Spring, Baker. The Heritage Foundation, interviewed by author, 30 December 1999.

"SS-N-22 'Sunburn (P-80/3m-80 Zubr)." *Jane's Strategic Weapons Systems*, vol. 29, 28 January 1999.

"Standard Missile-3 Completes First Test Flight." *Defense Systems Daily*, 28 Sep 99. URL <http://defence-data.com/archive/page5351.htm> accessed 15 November 1999.

U.S. General Accounting Office. *Report to Congressional Requesters: National Missile Defense Schedule and Technical Risks Represent Significant Development Challenges.* Washington, DC: GAO, 1997. GAO/NSIAD-98-28.

"USA/Ground Based Interceptor (EKV)." *Jane's Defensive Weapons Systems.* vol. 30. 21 May 1999.

U.S. Congress. House. *Executive Summary of the Report of the Commission to Assess the Ballistic Missile Threat to the United States*. 15 July 1998. URL <www.fas.org/irp/threat/bm-threat.htm> accessed 30 June 1999.

U.S. Congress, House, National Security Committee. *Statement of Lt General Malcolm R. Oneill, USA, Director Ballistic Missile Defense Organization: Ballistic Missile Defense: 12 Years of Achievement.* 4 April 1995, URL <www.defenselink.mil/speeches/1995/t19950404-oneill.html> accessed 9 February 2000.

U.S. Congress. Senate. Committee on Armed Services, Subcommittee on Strategic Forces, *Remarks of Ambassador David J. Smith.* 105th Cong., 2nd sess., 1998.

U.S. Congress. Senate. Senate Armed Services Committee, Strategic Forces Subcommittee. *Statement of LtGen Ronald T. Kadish.* 28 February 2000. URL <www.acq.osd.mil/bmdo/bmdolink/html/kadish28feb00.html> accessed on 1 March 2000.

Wall, Robert. “Future of Missile Defenses Lies In Advanced Technology.” *Aviation Week & Space Technology*, 16 Aug 99, 71.

Weiner, Stephen “Systems and Technology.” In *Ballistic Missile Defense.”* Eds. Ashton B. Carter and David N. Scwartz. Washington, DC: The Brookings Institute, 1984.

Whitley, Gigi. “After Months of Debate, Pentagon Tells Congress of New SBIRS Plans.” *Inside the Air Force*, 13 August 1999.